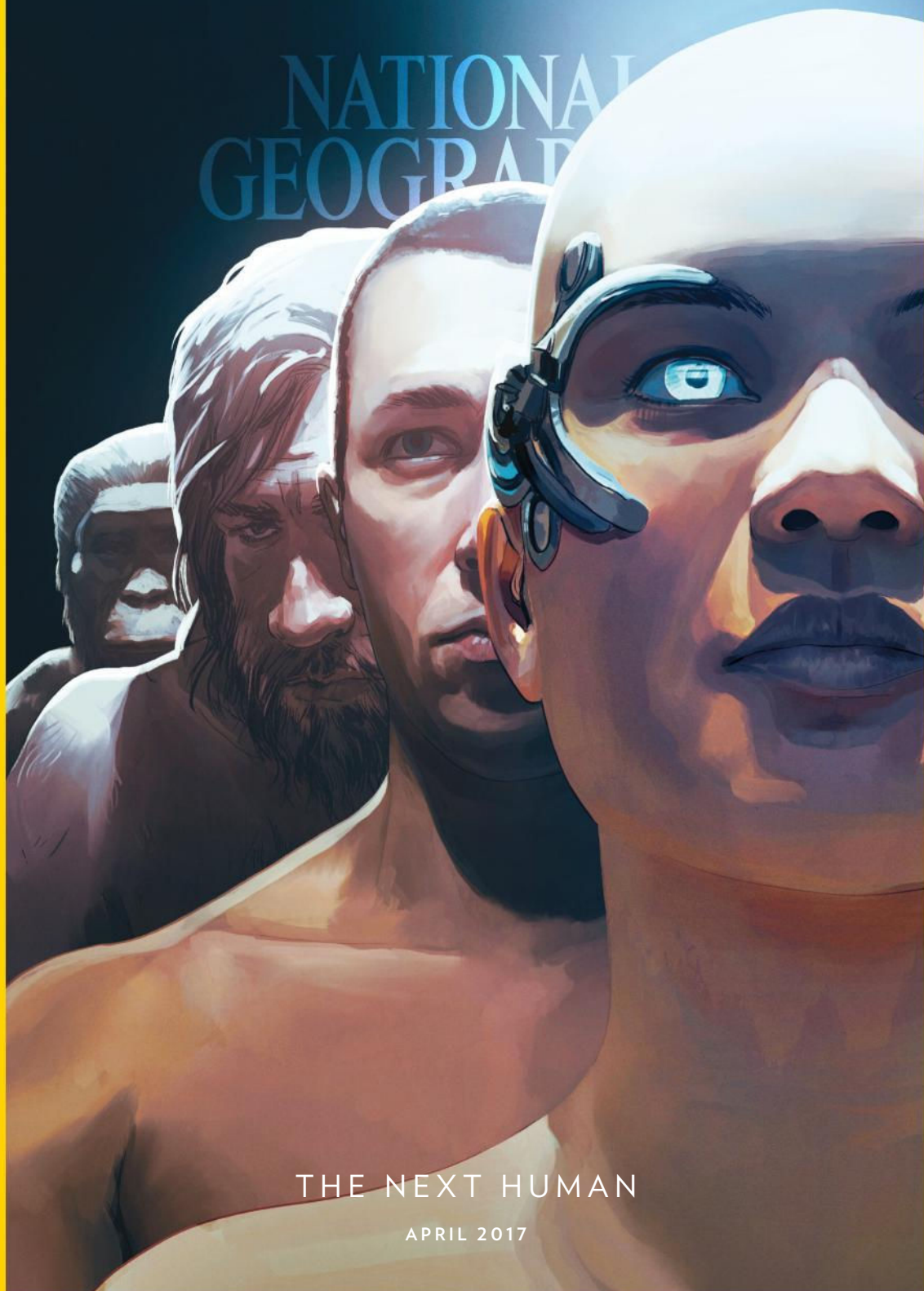


CLIMATE FACTS

| ALASKA ARTIFACTS

| SURVIVING ISIS

NATIONAL GEOGRAPHIC



THE NEXT HUMAN

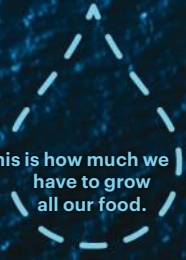
APRIL 2017



**UNCHARTED
WATERS**

Explore how farmers feed our growing population
with just 0.7% of the Earth's water^{1,2} at
[NationalGeographic.com/UnchartedWaters](https://www.nationalgeographic.com/UnchartedWaters)

Water is all we have on earth



this is how much we
have to grow
all our food.

**WINFIELD
UNITED**

**LAND O' LAKES
SUSTAIN**

1. "Feeding Ourselves Thirsty: How the Food Sector is Managing Global Water Risks," <http://www.ceres.org/issues/water/agriculture/water-risks-food-sector>. Accessed January 18, 2017. 2. National Oceanic and Atmospheric Administration, Science on a Sphere, "Blue Planet," <https://sos.noaa.gov/Datasets/dataset.php?id=284>. Accessed January 24, 2017. WinField United and Uncharted Waters are trademarks and WinField is a registered trademark of Winfield Solutions, LLC. © 2017 Winfield Solutions, LLC. Land O'Lakes SUSTAIN is a registered trademark of Land O'Lakes, Inc. © 2017 Land O'Lakes Inc

QUICKENLOANS.COM

DON'T GET HELD DOWN BY AN OUTDATED MORTGAGE PROCESS.
GO COMPLETELY ONLINE FOR A FAST, CONVENIENT APPROVAL.

GO WAITLESS



Quicken Loans Inc.; NMLS#3030; www.NMLSConsumerAccess.org. Equal Housing Lender. Licensed in 50 states. AR; TX: 1050 Woodward Ave., Detroit, MI 48226-1906, (888) 474-0404; AZ: 16425 North Pima, Ste. 200, Scottsdale, AZ 85260, Mortgage Banker License #BK-0902939; CA: Licensed by Dept. of Business Oversight, under the CA Residential Mortgage Lending Act and Finance Lenders Law; CO: Regulated by the Division of Real Estate; GA: Residential Mortgage Licensee #11704; IL: Residential Mortgage Licensee #4127 - Dept. of Financial and Professional Regulation; KS: Licensed Mortgage Company MC.0025309; MA: Mortgage Lender License #ML 3030; ME: Supervised Lender License; MN: Not an offer for a rate lock agreement; MS: Licensed by the MS Dept. of Banking and Consumer Finance; NH: Licensed by the NH Banking Dept., #6743MB; NV: License #626; NJ: Licensed Mortgage Banker - NJ Dept. of Banking, 1st (and/or 2nd) mortgages only; NY: Licensed Mortgage Banker - NYS Banking Dept.; OH: MB 850076; OR: License #ML-1387; PA: Licensed as a 1st Mortgage Banker by the Dept. of Banking and licensed pursuant to the PA Secondary Mortgage Loan Act; RI: Licensed Lender; WA: Consumer Loan Company License CL-3030. Rates subject to change. Restrictions may apply. ©2000 - 2017 Quicken Loans Inc. All rights reserved. Lending services provided by Quicken Loans Inc., a subsidiary of Rock Holdings Inc. "Quicken Loans" is a registered service mark of Intuit Inc., used under license.

| CONTENTS

APRIL 2017 • VOL. 231 • NO. 4 • OFFICIAL JOURNAL OF THE NATIONAL GEOGRAPHIC SOCIETY

FRONT

3 QUESTIONS

Geoffrey Rush on playing the “great part” of Einstein

VISIONS

EXPLORE: WATER

In the water: fish, trash, signs of stress. Out of water: people worldwide.

FEATURES

96 | LIFE AFTER ISIS

As Iraqi and coalition forces moved to retake Mosul in 2016, fleeing Iraqis told harrowing stories of the Islamic State’s brutal reign.

By James Verini Photographs by Moises Saman



On the Cover From Stone Age hunter-gatherers to today’s high-tech pioneers, humans increasingly have taken evolution into our own hands. Where will our species go next?
Illustration by Owen Freeman

Corrections and Clarifications
Go to natgeo.com/corrections.

30 | CLIMATE CHANGE: 7 THINGS YOU NEED TO KNOW

The scientific facts about threats to the planet and how to mitigate them.

72 | GRASS-EATING MONKEYS OF ETHIOPIA

A community aims to shield habitat that geladas need.

By Craig Welch
Photographs by Jeffrey Kerby and Trevor Beck Frost

40 | BEYOND HUMAN

Are humans still evolving? Yes, under the influence of culture and technology.

By D. T. Max
Illustrations by Owen Freeman

124 | TINY RUINS

Artists’ miniature tableaux depict abandoned cities gone to seed.

By Jeremy Berlin
Photographs by Lori Nix and Kathleen Gerber

64 | HOME ON THE RANGE

Modernity and tradition meet in a Pakistani village.

Story and Photographs by Matthieu Paley

134 | RACING THE THAW

Alaska natives hope to rescue ancestral artifacts before the sea takes them.

By A. R. Williams
Photographs by Erika Larsen

ELSEWHERE



NATIONAL GEOGRAPHIC BOOKS

MEET THE PASSENGERS OF THE PHOTO ARK

The waxy monkey tree frog above is one of more than 6,000 animals immortalized in portraits by photographer Joel Sartore, who is circling the globe in his quest to photograph every species in captivity. See hundreds of Sartore's colorful subjects in his new book, *The Photo Ark: One Man's Quest to Document the World's Animals*, available at shopng.com or wherever books are sold.

NAT GEO WILD

GO BARKING WILD FOR A WEEKEND

Nat Geo WILD's third annual BarkFest weekend is a celebration of furry best friends of all shapes and sizes. Tune in for canine capers all weekend long starting April 14 at 8/7c, on Nat Geo WILD.

NATIONAL GEOGRAPHIC BOOKS

TURN YOUR BAD DAY AROUND ...

...with 365 tales of other days that were worse. Michael Farquhar's *Bad Days in History*, now in paperback, lists "an instance of bad luck, epic misfortune, or unadulterated mayhem" for each day of the year. A grim April example: On the 20th in 1889, Adolf Hitler was born. *Bad Days* is available at shopng.com and wherever books are sold.

NATIONAL GEOGRAPHIC KIDS

TALKING TRASH TO HELP THE PLANET

In time for Earth Day, April 22: *THIS BOOK STINKS!* a colorful look at the science of trash. For ages eight through 12, it covers topics from composting to clever uses of rubbish. Available at shopng.com and wherever books are sold.

TELEVISION

WHO GETS WATER IN A DROUGHT?

This view of California's Central Valley – lush orchards across from fallow ones – embodies the point of *Water & Power: A California Heist*. The documentary examines the state's history of water manipulations and the risk they pose to vital U.S. farmlands. Watch it on National Geographic at 9 ET/PT on March 14. The facts behind *Water & Power* inspired the three-part series *Parched*, a report on global water issues. It airs on National Geographic at 10 ET/PT on March 21, March 28, and April 4.



NATGEO.COM VIDEO

A DAY IN THE LIFE OF A GELADA MONKEY

From the high cliffs above East Africa's Great Rift Valley to the misty plateau of Guassa, "bleeding heart" monkeys play, search for food, and explore the Ethiopian Highlands. See the video at ngm.com/Apr2017.

Subscriptions For subscriptions or changes of address, contact Customer Service at ngmservice.com or call 1-800-647-5463. Outside the U.S. or Canada call +1-813-979-6845. We occasionally make our subscriber names available to companies whose products or services might be of interest to you. If you prefer not to be included, you may request that your name be removed from promotion lists by calling 1-800-NGS-LINE (647-5463). To prevent your name from being available to all direct mail companies, contact Mail Preferences Service, c/o Direct Marketing Association, P.O. Box 9008, Farmingdale, NY 11735-9008.

Contributions to the National Geographic Society are tax deductible under Section 501(c)(3) of the U.S. tax code. | Copyright © 2017 National Geographic Partners, LLC | All rights reserved. National Geographic and Yellow Border: Registered Trademarks ® Marcas Registradas. National Geographic assumes no responsibility for unsolicited materials. Printed in U.S.A.

NATIONAL GEOGRAPHIC (ISSN 0027-9358) PUBLISHED MONTHLY BY NATIONAL GEOGRAPHIC PARTNERS, LLC, 1145 17TH ST. NW, WASHINGTON, DC 20036. ONE YEAR MEMBERSHIP: \$39.00 U.S. DELIVERY; \$44.00 TO CANADA, \$51.00 TO INTERNATIONAL ADDRESSES. SINGLE ISSUE: \$7.00 U.S. DELIVERY; \$10.00 CANADA, \$15.00 INTERNATIONAL. (ALL PRICES IN U.S. FUNDS; INCLUDES SHIPPING AND HANDLING) PERIODICALS POSTAGE PAID AT WASHINGTON, DC, AND ADDITIONAL MAILING OFFICES. POSTMASTER: SEND ADDRESS CHANGES TO NATIONAL GEOGRAPHIC, P.O. BOX 62130, TAMPA, FL 33662. IN CANADA, AGREEMENT NUMBER 40063649. RETURN UNDELIVERABLE ADDRESSES TO NATIONAL GEOGRAPHIC, P.O. BOX 4412, STN. A, TORONTO, ONTARIO M5W 3W2. UNITED KINGDOM NEWSSTAND PRICE £5.99. REPR. EN FRANCE, EMD FRANCE SA, BP 1029, 59011 LILLE CEDEX; TEL. 320.300.302; CPPAP 0715U89037; DIRECTEUR PUBLICATION: D. TASSINARI DIR. RESP. ITALY: RAPP IMD SRL, VIA G. DA VELATE 11, 20162 MILANO; AUT. TRIB. MI 258 26/5/84 POSTE ITALIANE SPA; SPED. ABB. POST. DL 353/2003 (CONV. L. 27/02/2004 N.46) ART. 1 C. 1 DCB MILANO STAMPA QUAD/GRAPHICS, MARTINSBURG, WV 25401. MEMBERS: IF THE POSTAL SERVICE ALERTS US THAT YOUR MAGAZINE IS UNDELIVERABLE, WE HAVE NO FURTHER OBLIGATION UNLESS WE RECEIVE A CORRECTED ADDRESS WITHIN TWO YEARS.

PHOTOS: JOEL SARTORE, PHOTO ARK (FROG);
BRYAN HARVEY AND TIM GOULD

THE DAY IS GIVEN. THE WHISKEY'S EARNED.



THIS CREEK RUNS FULL™

100 PROOF

CLERMONT  KENTUCKY

FULL FLAVOR

drink smart®

KNOB CREEK® KENTUCKY STRAIGHT BOURBON WHISKEY, 50% ALC./VOL. ©2017 KNOB CREEK DISTILLERY, CLERMONT, KY.

EDITOR IN CHIEF Susan Goldberg

DEPUTY EDITOR IN CHIEF Jamie Shreeve

MANAGING EDITOR David Brindley

EXECUTIVE EDITOR DIGITAL Dan Gilgoff

DIRECTOR OF PHOTOGRAPHY Sarah Leen

EXECUTIVE EDITOR NEWS AND FEATURES David Lindsey

CREATIVE DIRECTOR Emmet Smith

NEWS / FEATURES

SHORT-FORM DIRECTOR: Patricia Edmonds

EDITORS: Christine Dell'Amore, Peter Gwin, John Hoeffel, Victoria Jaggard, Robert Kunzig, Glenn Oeland, Oliver Payne

WRITERS: Jeremy Berlin, Eve Conant, Michael Greshko, Brian Clark Howard, Laura Parker, Kristin Romey, Rachel Hartigan Shea, Daniel Stone, Nina Strohlich, A. R. Williams, Catherine Zuckerman

ASSISTANT EDITOR: Natasha Daly

CONTRIBUTING WRITERS: Nadia Drake, Robert Draper, Cynthia Gorney, David Quammen, James Verini, Craig Welch

SPECIAL INVESTIGATIONS: Rachael Bale, Jani Actman

PHOTOGRAPHY

DEPUTY DIRECTORS: Whitney C. Johnson, Patrick Witty

BUSINESS MANAGER: Allison Bradshaw

SENIOR PHOTO EDITORS: Kathy Moran (Natural History), Kurt Mutchler (Science), Jamie Wellford (Global Issues);

Todd James, Alexa Keefe, Sadie Quarrier, Molly Roberts, Vaughn Wallace, Jessie Wender, Nicole Werbeck

ASSOCIATE PHOTO EDITORS: Matt Adams, Mallory Benedict, Adrian Coakley, Jehan Jillani, David Y. Lee, Jennifer Pritheva Samuel, Elijah Walker

ASSISTANT PHOTO EDITOR: Julie Hau

STAFF PHOTOGRAPHERS: Rebecca Hale, Mark Thiessen

DIGITAL IMAGING: Christina Micek, Edward Samuel

PHOTO ENGINEER: Tom O'Brien

PHOTO COORDINATORS: Edward Benfield, Kaya Lee Berne, Elena Sheveiko

ADMINISTRATION: Veronica Kresse

DIGITAL PUBLISHING

CREATIVE DIRECTOR: Bethany Powell

VICE PRESIDENT VIDEO: James Williams

PROGRAMMING DIRECTOR: Alissa Swango

UX DIRECTOR: Luke Miller

SENIOR DESIGNERS: Liz Calka, Kevin DiCesare, Vitomir Zarković

DESIGNERS: Scott Burkhard, Lauren Glazer

CREATIVE DEVELOPER: Chan Young Park.

DIGITAL PRODUCERS: Janey Adams, Heather Brady, Delaney Chambers, Jess Estepa, Sarah Gibbens, John Kondis, Francis Rivera

VIDEO PRODUCERS: Jeff Hertrick; Stephanie Atlas, James Burch, Kathryn Carlson, Gabrielle Ewing, Gabriella Garcia-Pardo, Will Halicks, Rachel Link, Nick Lunn, Edythe McNamee, Jennifer Murphy, Jed Winer

PRODUCTION MANAGERS: Lisa Covi, Trish Dorsey

COORDINATORS: Rachel Brown, Sandra Oyenerin

OPERATIONS / FINANCE

ASSISTANT TO EDITOR IN CHIEF: Joey Wolfkill

BUSINESS OPERATIONS: Cole Ingraham; Jacqueline Rowe, Edwin Sakyi

FINANCE: Jeannette Swain; Nikisha Long; Jocelyn Buckner, Leticia Rivera

COMMUNICATIONS

DIRECTORS: Ann Day, Anna Kukulhaus Dynan

NATIONAL GEOGRAPHIC CREATIVE VICE PRESIDENT:

Alice Keating; Mimi Dornack, Stacy Gold, John Rutter

CONTENT STRATEGY VICE PRESIDENT: Dave E. Smith

SENIOR BUSINESS ANALYST: Gina L. Cicotello

SYSTEMS: Robert Giroux, Patrick Twomey

CONSUMER MARKETING

EXECUTIVE VICE PRESIDENT: Terrence Day

SENIOR VICE PRESIDENT MEMBER MARKETING:

Elizabeth M. Safford

VICE PRESIDENTS: John MacKethan, John A. Seeley

DIRECTORS: Anne Barker, Richard Brown, Tracy Pelt

NATIONAL GEOGRAPHIC SOCIETY

The National Geographic Society is a global nonprofit membership organization committed to exploring and protecting our planet.

PRESIDENT AND CEO Gary E. Knell

BOARD OF TRUSTEES

CHAIRMAN: Jean N. Case

VICE CHAIRMAN: Tracy R. Wolstencroft
Brendan P. Bechtel, Michael R. Bonsignore, Alexandra Grosvenor Eller, Gary E. Knell, Jane Lubchenco, Mark C. Moore, George Muñoz, Nancy E. Pfund, Peter H. Raven, Edward P. Roski, Jr., Frederick J. Ryan, Jr., Ted Waitt, Anthony A. Williams

INTERNATIONAL COUNCIL OF ADVISORS

Darlene T. Anderson, Michael S. Anderson, Sarah Argyropoulos, Lucy and Henry Billingsley, Richard C. Blum, Sheila and Michael Bonsignore, Diane and Hal Brierley, Howard G. Buffett, Pat and Keith Campbell, Jean and Steve Case, Alice and David Court, Barbara and Steve Durham, Warren H. Haruki, Joan and David Hill, Lyda Hill, David H. Koch, Sven Lindblad, Juli and Tom Lindquist, Claudia Madrazo de Hernandez, Pamela Mars Wright, Edith McBean, Susan and Craig McCaw, Mary and Gregory M. Moga III, Mark C. Moore, Pearl and Seymour Moskowitz, Timothy S. Nash, Caryl D. Phillips, Mark Pruzanski, Gayle and Edward P. Roski, Jr., Jeannie and Tom Rutherford, Vicki Sant, Jessica and Richard Sneider, Philip Stephenson, Mary Hart and Burt Sugarman, Clara Wu Tsai, Garry Weber, Angie and Leo Wells, Judith and Stephen Wertheimer, Tracy R. Wolstencroft, B. Wu and Eric Larson, Jeffrey M. Zell

RESEARCH AND EXPLORATION COMMITTEE

CHAIRMAN: Peter H. Raven

Paul A. Baker, Kamajit S. Bawa, Colin A. Chapman, Janet Franklin, Carol P. Harden, Kirk Johnson, Jonathan B. Losos, John O'Loughlin, Steve Palumbi, Naomi E. Pierce, Jeremy A. Sabloff, Monica L. Smith, Thomas B. Smith, Christopher P. Thornton, Wirt H. Smith

EXPLORERS-IN-RESIDENCE

Robert Ballard, Lee R. Berger, James Cameron, Sylvia Earle, J. Michael Fay, Beverly Joubert, Dereck Joubert, Louise Leakey, Meave Leakey, Enric Sala

FELLOWS

Dan Buettner, Bryan Christy, Fredrik Hiebert, Zeb Hogan, Corey Jaskolski, Mattias Klum, Thomas Lovejoy, Sarah Parcak, Paul Salopec, Joel Sartore

NATIONAL GEOGRAPHIC PARTNERS

CEO Declan Moore

SENIOR MANAGEMENT

CHIEF MARKETING OFFICER: Jill Cross

EDITORIAL DIRECTOR: Susan Goldberg

SVP STRATEGIC PLANNING AND BUSINESS DEVELOPMENT: Whit Higgins

CHIEF FINANCIAL OFFICER: Marcela Martin

GLOBAL NETWORKS CEO: Courteney Monroe

CHIEF COMMUNICATIONS OFFICER: Laura Nichols

EVP BUSINESS AND LEGAL AFFAIRS: Jeff Schneider

EVP DIGITAL PRODUCT: Rachel Webber

EVP CONSUMER PRODUCTS AND EXPERIENCES: Rosa Zeegers

BOARD OF DIRECTORS

CHAIRMAN: Peter Rice

Jean N. Case, Randy Freer, Gary E. Knell, Kevin J. Maroni, James Murdoch, Lachlan Murdoch, Frederick J. Ryan, Jr.



WE BELIEVE IN THE POWER OF SCIENCE,
EXPLORATION, AND STORYTELLING
TO CHANGE THE WORLD.

DESIGN

DIRECTOR: Michael Tribble

SENIOR DESIGN EDITORS: John Baxter, Elaine H. Bradley

DESIGN EDITOR: Hannah Tak

ASSOCIATE DESIGN EDITORS: Sandi Owatverot-Nuzzo, Nicole Thompson

ART / GRAPHICS

DIRECTOR: John Tomanio

SENIOR GRAPHICS EDITORS: Fernando G. Baptista,

Manuel Canales, Kennedy Elliott, Alberto Lucas López,

Monica Serrano, Jason Treat

GRAPHICS EDITOR: Daniela Santamarina (Production)

ASSOCIATE GRAPHICS EDITORS: Riley Champine,

Daisy Chung

RESEARCHER: Ryan Williams

CARTOGRAPHY

DIRECTOR: Damien Saunderson

DIRECTOR OF CARTOGRAPHIC DATABASES:

Theodore A. Sickley

SENIOR CARTOGRAPHY EDITORS: Ryan Morris

(Interactives); Matthew W. Chwastyk, Brian Jacobs

CARTOGRAPHY EDITOR: Lauren E. James

MAP EDITORS: Irene Berman-Vaporis, Rosemary P. Wardley,

Scott Zillmer

COPY / RESEARCH

DEPUTY MANAGING EDITOR: Amy Kolczak

RESEARCH DIRECTOR: Alice S. Jones

COPY EDITORS: Preeti Aroon, Cindy Leitner,

Mary Beth Oelkers-Keegan

RESEARCHERS: Elizabeth S. Atalay, Taryn L. Salinas,

Heidi Schultz, Brad Scriber

PRODUCTION SERVICES

SENIOR VICE PRESIDENT: Phillip L. Schlosser

IMAGING VICE PRESIDENT: Thomas J. Craig;

Wendy K. Smith; Rahsaan J. Jackson

QUALITY TECHNICAL DIRECTOR: Clayton R. Burneston;

Michael G. Lappin, William D. Reicherts

DISTRIBUTION AND ADVERTISING PRODUCTION:

Kristin M. Semeniuk

BUSINESS MAGAZINE DIRECTOR: Greg Storer

INTERNATIONAL EDITIONS

DEPUTY EDITORIAL DIRECTOR: Darren Smith

TRANSLATION MANAGER: Beata Kovacs Nas

EDITORS: ARABIC: Alsaad Omar Almenhaly. BRAZIL:

Ronaldo Ribeiro. BULGARIA: Krassimir Drumev. CHINA:

Ai Shaoqing. CROATIA: Hrvoje Prčić. CZECHIA: Tomáš

Tureček. ESTONIA: Erkki Peetsalu. FARSI: Babak Nikkhal

Bahrami. FRANCE: Jean-Pierre Vriegnaud. GEORGIA: Levon

Butkhuzi. GERMANY: Florian Giess. HUNGARY: Tamás Vitray.

INDIA: Niloufer Venkatraman. INDONESIA: Didi Kaspi Kasim.

ISRAEL: Daphne Raz. ITALY: Marco Cattaneo. JAPAN:

Shigeo Otsuka. KAZAKHSTAN: Yerkin Zhakipov. KOREA:

Junemo Kim. LATIN AMERICA: Claudia Muzzi Turullols.

LITHUANIA: Frederikas Jansonas. NETHERLANDS/BELGIUM:

Aart Aarsbergen. NORDIC COUNTRIES: Karen Gunn.

POLAND: Agnieszka Franus. PORTUGAL: Gonçalo Pereira.

ROMANIA: Catalin Gruia. RUSSIA: Andrei Palamarchuk.

SERBIA: Igor Riil. SLOVENIA: Marija Javornik. SPAIN: Josep

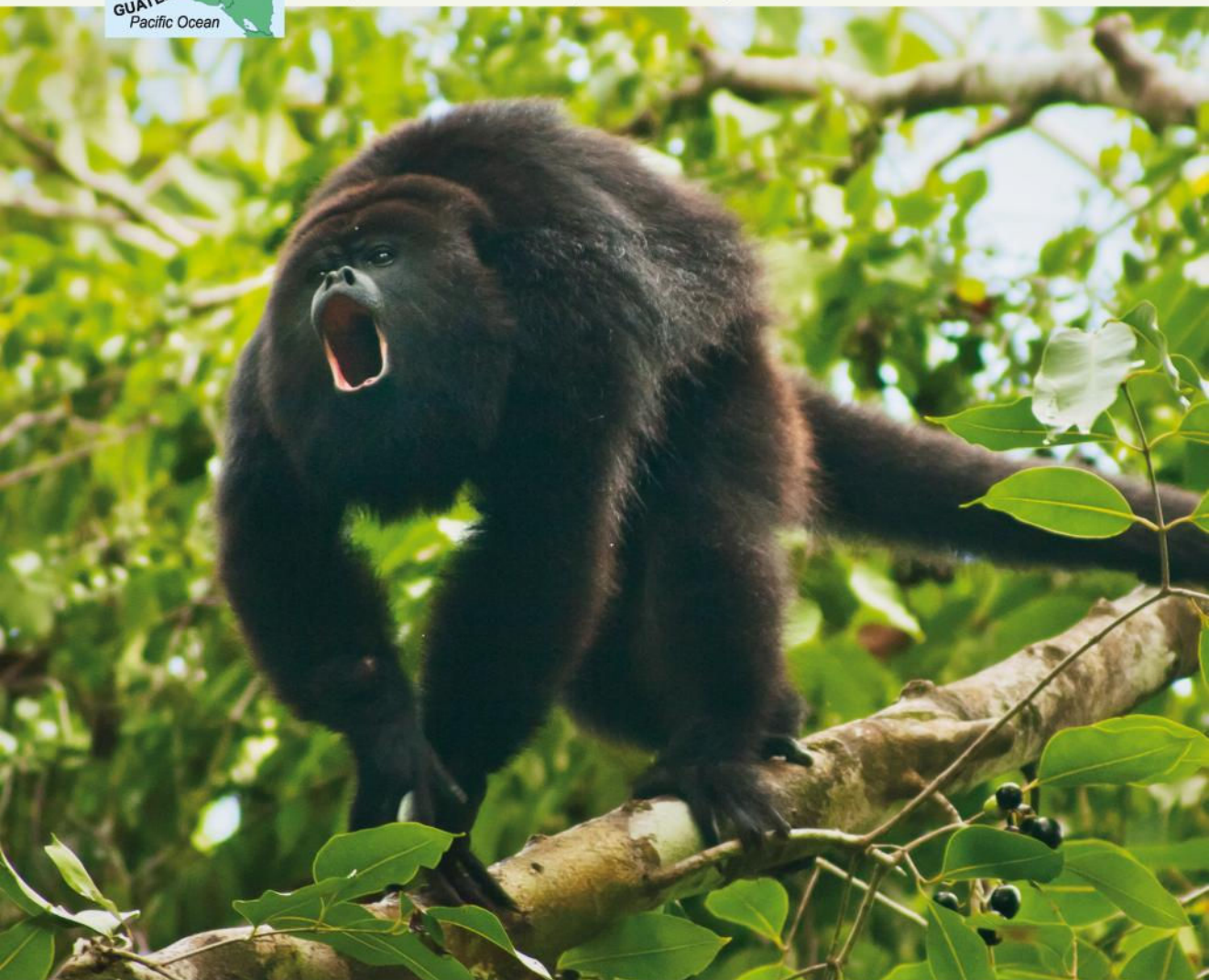
Cabello. TAIWAN: Yungshih Lee. THAILAND: Kowit

Phadungrangkij. TURKEY: Nesibe Bat



Yucatán Black Howler Monkey (*Alouatta pigra*)

Size: Head and body length, 41.5 - 64 cm (16.3 - 25.2 inches); tail, 49.8 - 63 cm (19.6 - 24.8 inches) **Weight:** 7 - 10 kg (15.4 - 22 lb) **Habitat:** Primary terra firma rain forest, semi-deciduous tropical forest, riparian forest, seasonally flooded riparian areas and swamps, and mature secondary forest **Surviving number:** Unknown



Photographed by Kevin Schafer

WILDLIFE AS CANON SEES IT

Born noisemakers. Every day in the early morning and at dusk, Yucatán black howler monkey troops let loose a chorus of loud rumbles, growls and howls; the crescendo can be heard over a mile away. Both males and females use their specialized voice boxes to howl, with males demonstrating their howling prowess to show dominance and ward off interloping males from

other groups. But these decibel-raising denizens of the forest canopy are falling silent in alarming numbers due to deforestation, habitat disturbance and hunting.

As Canon sees it, images have the power to raise awareness of the threats facing endangered species and the natural environment, helping us make the world a better place.



EOS System

Canon

OUR SOCIAL MEDIA MISSION

At National Geographic, we want to be part of the conversation. We do that by creating stories for our magazines and *nationalgeographic.com* that are timely, memorable, and important. Our recent coverage of the refugee crisis, the gender revolution, and climate change are examples of meeting that objective.

But today, to be in conversation with the widest possible audience, we need to be a player on social media as well.

We're proud that for most of the past two years, National Geographic has ranked number one among brands on social media in the United States. With more than 2.6 billion social engagements, we're right up there with the NFL, the NBA, and Victoria's Secret.

Our largest publishing platforms, outside of our own properties, are Facebook, Instagram, Twitter, and Snapchat. We approach each differently, customizing content to meet the unique expectations and desires of each site's users. For example, our Snapchat audience—mostly younger people—wants a more kinetic, high-energy approach to information than our audience on Facebook.

And then there's Instagram. Given that we're famous for visual storytelling, perhaps it's not surprising that our main account—@NatGeo, which is run by our photographers—is taking almost 67 million followers on virtual journeys all over the world.

"One moment you'll be underwater, face-to-face with a whitetip shark, and the next moment you'll be atop a volcano in Rwanda with a family of mountain gorillas," says Patrick Witty, our deputy director of digital photography, who manages the account. "Through @NatGeo we help people experience the planet and cultures as seen by our photographers—a special, unfiltered view."

We also see a great future with 360-degree video and virtual reality. The fully



immersive experiences we've created so far include a close look at an erupting volcano and the first ever VR event with a sitting president.

What do our audiences want to see? The photo above is a good example. Randy Olson shot it while on assignment for a story on the Ogallala aquifer, which ran in our August 2016 issue. Putting the photo on Instagram gave it new life. More than 1.3 million people "liked" it, making it one of the year's most liked images.

We've come a long way since 1906, when Editor Gilbert H. Grosvenor's bold use of photos in the magazine prompted two National Geographic board members to resign. In all those years, though, one thing hasn't changed: our commitment to storytelling that brings you the world.

A storm lights Nebraska's Platte River as hundreds of thousands of cranes rest for the night. The image was among the most popular on the @NatGeo Instagram account in 2016.

Find the book @NatGeo at shopng.com/natgeobook, or wherever books are sold. And until April 30, 2017, see the exhibit "@NatGeo: Popular Instagram Photos" at the National Geographic Museum, Washington, D.C.



Susan Goldberg, *Editor in Chief*



©2017 Blue Buffalo Co., Ltd.



BLUE Wilderness is made with more of the chicken, duck or salmon dogs love.

All dogs are descendants of the wolf, which means they share many similar traits – including a love for meat. That's why we created BLUE Wilderness.

Made with the finest natural ingredients, BLUE Wilderness is formulated with a higher concentration of the chicken, duck or salmon dogs love. And BLUE Wilderness has none of the grains that contain gluten.

If you want your dog to enjoy a meat-rich diet like his ancestors once did, there's nothing better than BLUE Wilderness.

WildernessDogFood.com



Love them like family. Feed them like family.®

PLAYING THE PART OF GENIUS

His acting roles have ranged from Captain Barbossa in the *Pirates of the Caribbean* movies to George VI's speech therapist in *The King's Speech*. But **Geoffrey Rush**, 65, says that portraying Albert Einstein in the television series *Genius* is "what actors call a great part. For a sexagenarian character actor, they don't come along every day."



How was Einstein unlike most of us?

In preparing for the role, I found the most fantastic, pithy expression, from the philosopher Arthur Schopenhauer: "Talent hits a target no one else can hit. Genius hits a target no one else can see." That's absolutely a description of Einstein's mind, because he overturned hundreds of years of scientific orthodoxies about gravity, light, space, time. Another aspect of being seen as a genius is endurance. He was still working on unified field theory into his 70s, and on his deathbed he was still trying to find what we would now call the theory of everything.

What might we have in common?

When Einstein died, they dissected his brain and found it was a normal weight—about 1.23 kilos [2.7 pounds]. I think they were expecting to find he had a massive frontal cortex or something. He was said to have a very high IQ: 160—about the same as [theoretical physicist Stephen] Hawking. He had a lot of human frailties. He had ego, he had doubt, he had sadness. He suffered the deaths of many loved ones in his life span, massive marital problems, estrangement from his children. He was vulnerable to all the contradictions that every human can be.

Can you imagine yourself in conversation with him, or sharing a meal?

It's a parlor game, really, isn't it? The fantasy of having historical dinner guests. He'd be on my list alongside Plato, Shakespeare, Charlie Chaplin, and Queen Elizabeth I. I just hope he'd accept the invitation, because he was obsessed by the need for solace for what his exploratory brain demanded of him. But he was also gregarious; he quipped absurdities and made wisecracks like Groucho Marx. In terms of the meal: I have German ancestry too, and I like schnitzel, strudel, my grandmother's sauerkraut... So that's probably what I'd suggest. And I think he'd join in heartily.

The 10-part series *Genius* airs Tuesdays starting April 25, on National Geographic.



COME VISIT A WORLD

BEYOND BELIEF

SOAR ON THE BACK OF A BANSHEE

NAVIGATE A MYSTICAL RIVER

CLIMB UNDER FLOATING MOUNTAINS

PANDORA

THE WORLD OF AVATAR

EXPEDITIONS BEGIN MAY 27

Walt Disney World.

VisitPandora.com

I VISIONS



Order prints of select *National Geographic* photos online at [NationalGeographicArt.com](https://www.NationalGeographicArt.com).



Japan

Matabei Sakura – a flowering, centuries-old cherry tree in Uda – blossoms beneath a starry sky in this long-exposure shot. Over 40 feet tall, with a trunk 10 feet around, the tree is named for a samurai warrior who died in the 17th century.

SYLVIA EARLE





WHEN YOUR
DISCOVERIES
INSPIRE
GENERATIONS,
YOU'VE MADE
HISTORY.

This watch is a witness to hidden worlds, and extraordinary discovery. Worn by an explorer who has spent a lifetime under the ocean. It doesn't just tell time. It tells history.



OYSTER PERPETUAL LADY-DATEJUST 28



ROLEX



CHALLENGE #NGMH2O

For this month's water theme, we asked the Your Shot community to submit images of water – as broad and far as it took them.

Hiro Kurashina
Barrigada, Guam

In Waikiki, Hawaii, where Kurashina and his wife were celebrating their 20th wedding anniversary, they wandered through an aquarium. The fish, rays, diver's fins, and tourists were all in the frame at once. "Somehow they came together spontaneously when I took the shot," he says.

**SOME MOUNTAINS MAKE
US BETTER. SOME MAKE
THE WORLD BETTER.**

▲ CLIMB ON



**GREAT BEER
GREAT RESPONSIBILITY®**

©2017 COORS BREWING CO., GOLDEN, CO

EXPLORE

WATER

GARBAGE SWELL

By Catherine Zuckerman

Outdoor photographer Zak Noyle has seen his share of marine debris, but he was shocked by what he discovered on an assignment in a remote spot off the coast of Java. There to cover Indonesian surfer Dede Suryana (right) in 2012, Noyle found himself literally swimming in a sea of garbage. “It was overwhelming,” he recalls. “I really thought we were going to see a dead body in the water.”

Roughly eight million tons of plastic enters the ocean every year. That’s according to a 2015 report, which also identified where the bulk of this trash originates. At the top of the list: China, the Philippines, and Indonesia.

Sightings of junk-filled waters are common—and not only in Southeast Asia, says marine biologist Nicholas Mallos, who runs the Ocean Conservancy’s Trash Free Seas program. “Accumulations like this are unfortunately the norm,” he says, particularly in developing parts of the world where there are “rising middle-class populations along coastlines, and spending and consumption have increased, but waste management has not.”

Though trash remains a global problem, Mallos sees reasons to be hopeful. In the United States, for example, California voters in 2016 upheld a statewide ban on plastic bags. And in Indonesia, he says, there has been a shift in awareness: “We’re seeing an eager and willing group of stakeholders who are trying to step up and tackle these issues.” Put another way: The tide may be turning.





FISH FOR THOUGHT

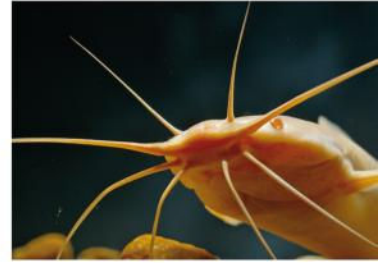
By Catherine Zuckerman

Hundreds of millions of people worldwide would lack their prime source of protein without freshwater fish. Yet the lakes and river systems that supply them are often overlooked by policymakers, who focus sustainability efforts instead on ocean species.

Marine fisheries tend to be commercial operations, while freshwater fishing is almost exclusively a means of subsistence. “Most freshwater fish catches don’t enter the global trade economy, so they draw less interest,” says University of Wisconsin–Madison zoologist Peter McIntyre.

McIntyre recently conducted a global analysis of riverine fisheries—and the threats they face—and determined there is an urgent need to safeguard these regions. He and his team found that 90 percent of the global freshwater catch comes from ecosystems that are stressed by “above average” pollution, dambuilding, and invasive species.

Nowhere are these challenges more



potentially damaging than within Southeast Asia’s multicountry Mekong River system—the world’s biggest freshwater fishery. There, says McIntyre, many people rely on catfish and other river species as a critical source of dietary protein that could not easily be replaced.

McIntyre’s research does not point to a “sky is falling” scenario, he says, but it is clear now that “the places getting hammered the hardest are the places where we have the most to lose.”

Examples of freshwater fish include (clockwise from top left) common bream, giant pangasius, walking catfish, and tilapia.

FISH PHOTOS (CLOCKWISE FROM TOP LEFT): WILL MEINDERTS, BUITENBEELD/MINDEN PICTURES; JOEL SARTORE, NATIONAL GEOGRAPHIC PHOTO ARK; ROBERT SISSON, NATIONAL GEOGRAPHIC CREATIVE; IAN NICHOLS, NATIONAL GEOGRAPHIC CREATIVE. DRINK PHOTO: REBECCA HALE, NGM STAFF

HYDRATION STATION: WHAT DRINK DOES THE JOB BEST?

Move over, glycemic index. British researchers are creating a beverage hydration index. The less a drink is peed out over two hours, the higher its “BHI” compared with water, rated “1.” Minerals and nutrients, like sodium and casein protein in milk, can raise the score. Fun fact: Researcher Stuart Galloway says a few cups of beer or tea can be as hydrating as water.

—Eve Conant





LEAVE YOUR FAMILY A BETTER WORLD

Family comes first when planning your legacy, which is why many people decide to leave a gift to the National Geographic Society in their will or trust. It's a wonderful way to **change your family's world** for generations to come.



COPYRIGHT © 2017 NATIONAL GEOGRAPHIC SOCIETY
MICHAEL NICHOLS/NATIONAL GEOGRAPHIC CREATIVE

CREATE A LEGACY OF YOUR OWN

- Yes! Please send me information on leaving a gift to the National Geographic Society.
- The National Geographic Society has already been included in my estate plans.
- I would like to speak to someone about making a gift. Please call me.

Mail to: National Geographic Society
Office of Planned Giving
1145 17th Street, N.W.
Washington, D.C. 20036-4688

Contact: plannedgiftinfo@ngs.org
(800) 226-4438
nationalgeographic.org/give/future-gifts

NAME

ADDRESS

PHONE

EMAIL

The National Geographic Society is a 501(c)(3) non-profit organization. Our federal tax ID number is 53-0193519.

17PGFC04B

FRESHWATER AT THE SOURCE

By Daniel Stone

Most people don't have the opportunity to swim in aquifers, but National Geographic Young Explorer Jennifer Adler regularly takes the plunge in hopes of promoting a new "water ethic," an enlightened mind-set about the different sources and uses of water.

She chiefly studies—and swims in—the Floridan aquifer, a body that supplies more than 90 percent of Florida's drinking water. After her dives she brings

photos, videos, and a 360-degree virtual underwater tour to nearby schools with lessons about water conservation and efficiency. Kids can be particularly curious about where water comes from, and urging kids to use less water is often an easier sell than persuading adults to go easy on their lawns.

What do children see in her images of underwater caves with almost no light or marine life? "Often not much more than a bunch of rock," she says. "A lot of kids ask me if I ever find gems." Her finds tend more to sand dollar fossils. The real treasure, as she hopes the kids understand, is the H₂O itself.

360° VIDEO

Explore Florida caves in this online experience at walkingonwaterfl.org/virtual-tour.

Adler takes regular dives in the Floridan aquifer for material to teach students about where water comes from—and why it's scarce.

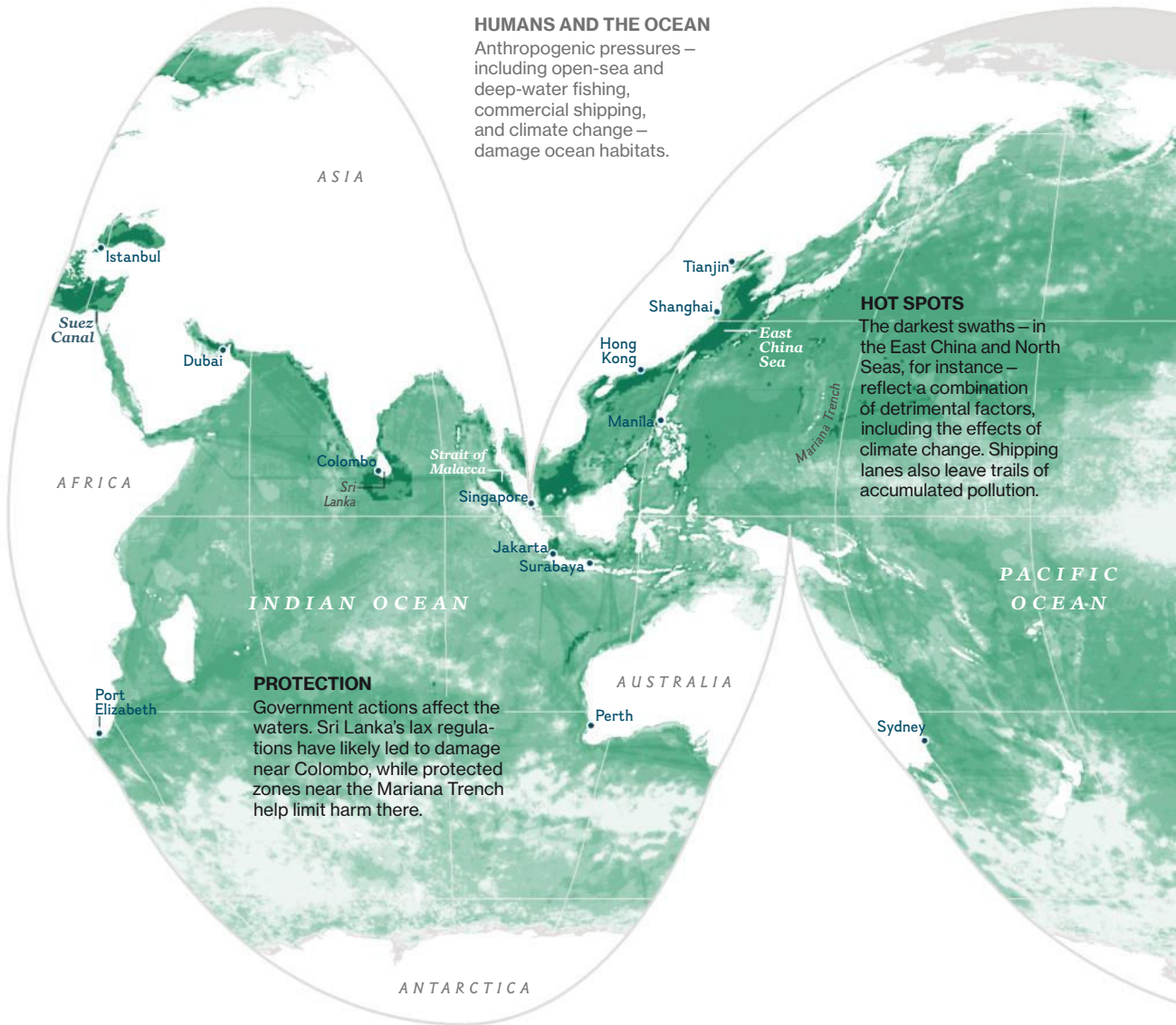
PHOTO: JENNIFER ADLER





THE TASTE OF APPLES AND STRAWBERRIES.
THE GREATEST COMBINATION SINCE
"HECK" MET "YEAH."





HUMANS AND THE OCEAN

Anthropogenic pressures – including open-sea and deep-water fishing, commercial shipping, and climate change – damage ocean habitats.

HOT SPOTS

The darkest swaths – in the East China and North Seas, for instance – reflect a combination of detrimental factors, including the effects of climate change. Shipping lanes also leave trails of accumulated pollution.

PROTECTION

Government actions affect the waters. Sri Lanka's lax regulations have likely led to damage near Colombo, while protected zones near the Mariana Trench help limit harm there.

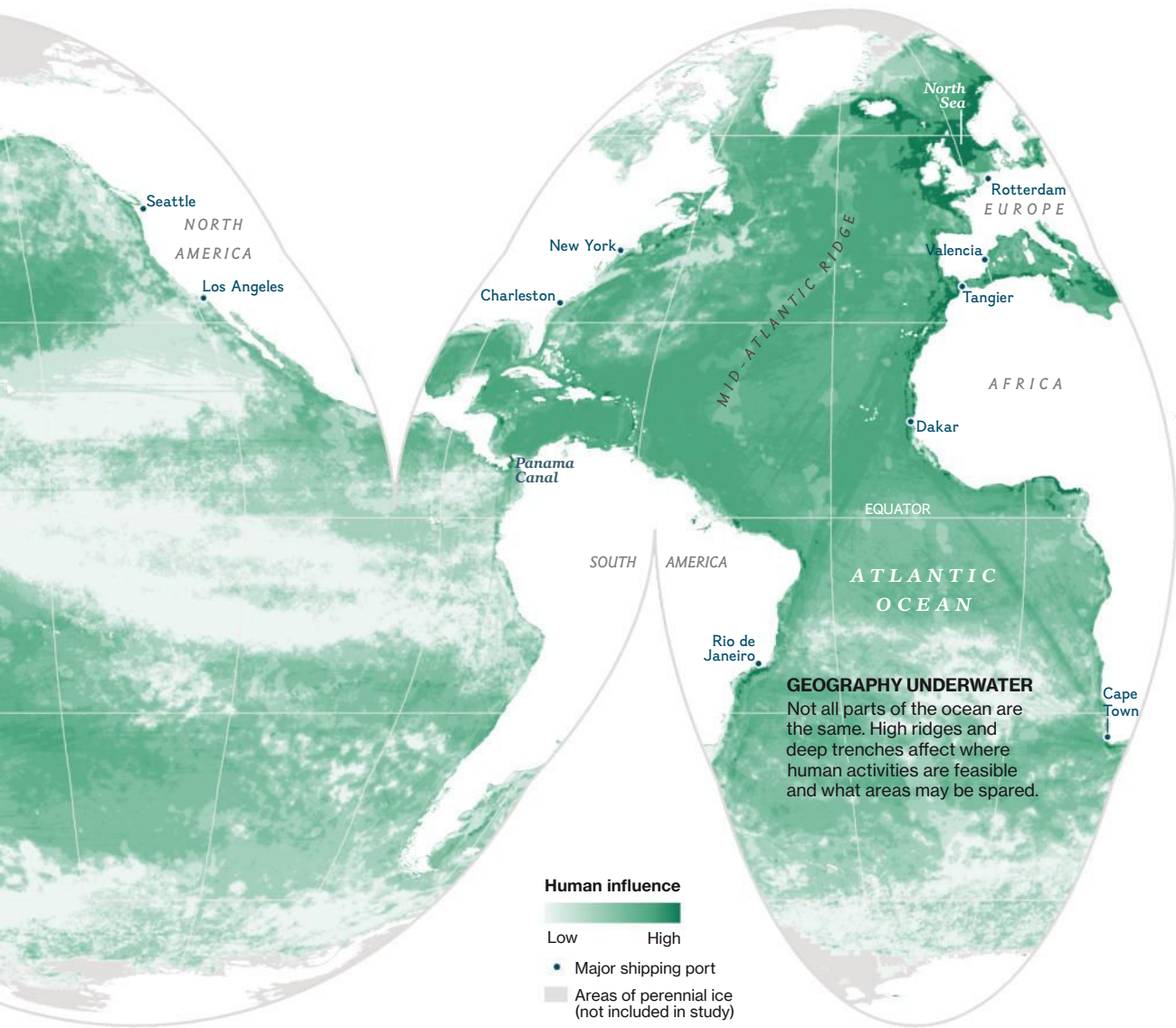
TROUBLED WATERS

By Daniel Stone

The map above is essentially an x-ray of the ocean, and the colors show where it's feeling the most impact from human activity. The darker the area, the more stressed the waters are by fishing, shipping, the destabilizing effects of climate change, or all three.

Such a map is rare. The vastness and

depth of the ocean make it notoriously difficult to study. But in 2008 a team of researchers used satellite images and modeling software to make a complete portrait of human effects on the ocean. Five years later they did it again, capturing a comprehensive view of an ocean in transition. Among the revelations: Two-thirds of the ocean shows increased strain from human-related factors, such as fishing and climate change. And more than three-quarters of coastal waters suffer from climate change and increases



in the effects of harmful land-based activities, including pollution. In all, the researchers classified more than 40 percent of the ocean as “heavily impacted” by human activity.

A booming population is chiefly to blame, says biologist Ben Halpern, head of the team that collected the data. Most of the dark areas are in the Northern Hemisphere, where almost 90 percent of humans live. But population alone doesn’t affect marine life. “A lot of the ocean is getting worse, and climate

change in particular is driving a lot of those changes,” says Halpern.

Still, the story isn’t all bad. Some seas have seen reduced human impact—in parts of the North Atlantic, for example, where there are more fuel-efficient ships and new regulations. In 2016 countries established more than 40 new sites to create more than 1.4 million additional square miles of protected marine areas, shielding much of it from commercial fishing, energy drilling, and other activities that might otherwise do harm.



DEEP-SEA VINO

By Nina Strohlic

In 2010 Dominique Demarville, cellar master for the champagne house *Veuve Clicquot*, got what he thought was a joke call: 168 bottles of likely the world's oldest champagne had been found in a shipwreck beneath the Baltic Sea.

Soon Demarville was sniffing and sipping the 170-year-old champagne, which he found sweet and fresh, although some tasters described its initial scent as "wet hair." The dark, cool sea had preserved it in what researchers called "close to perfect" conditions. Four years later

Veuve Clicquot launched *Cellar in the Sea*. Some 350 bottles were submerged in the Baltic, to be retrieved and analyzed periodically over 40 years.

Connoisseurs have long suspected that wine ages differently underwater. Analyses from a 10,000-bottle-capacity cellar off the Spanish coast by a company called *Bajoelagua Factory* show that factors like atmospheric pressure and water currents change the chemical compounds in wine.

Napa's *Mira Winery* conducted its own taste tests on 240 bottles in Charleston Harbor. When the first case was pulled up in 2013, a sommelier told owner Jim Dyke: "You've turned a 2009 cabernet into a 2007 in three months."

Cages of sparkling wine by Italian maker *Bisson* are kept in the Mediterranean for up to 18 months, leaving the bottles covered in algae.

WITH VENTURE[®], YOU EARN UNLIMITED DOUBLE MILES ON

MOVIES, HAMMERS, PET ROCKS, THROW RUGS, JEANS, CARS, BASKETBALLS, HOME REPAIRS, VIDEO TRAIN TICKETS, FLOWERS, IRON SKILLETTS, ROCKING CHAIRS, BOATS, RECORD PLAYERS, COMIC BOOKS, COOKING LESSONS, BRUNCH, SOCKET WRENCHES, BABY FOOD, DIGITAL CAMERAS, RAINCOATS, T-SHIRTS, ROOMS, HAIRSPRAY, DRIVING LESSONS, VIDEO GAMES, TOYS, DIRTY BIKES, MINIATURE GOLF, FAST FOOD, PHONE CHARGERS, FOOTBALL TICKETS, RESTAURANTS, COMPUTERS, T-SHIRTS, SKIS, SHOWER CAPS, SHIRTS, HOLIDAY CAKES, NAIL POLISH, TIRE ROTATING, SHINING TOOLS, STROLLERS, ALBUMS, SNOWBOARDS, MOVIE RENTALS, BBQ GRILLS, BATTERIES, BIRTHDAY PARTIES, SEUM ADMISSION, RINGS, WASHING MACHINES, WASHER FLUID, LAMPS, SUPPLIES, SNOW PANTS, MASSAGES, BAGS, SUITS, BOOTS, CABINETS, FERTILIZER, SLUSHIES, KITCHEN TABLES, KATEBOARDS, FRESH LOBSTER, BOWLING BALLS, ART SUPPLIES, COOKERS, TENTS, TREADMILLS, BRACELETS, CAR SEATS, SUSHI, TOSTOS, GOLFING, YOGA CLASSES, CELLPHONES, DISHWASHERS, EYEGASSES, PLUMBERS, GUITARS, SMARTPHONES, CAMERAS, GARDENING TOOLS, AMOUNTS, FLATWASHERS, CEREAL, FRAMES, TRAMPOLINES, PERSIAN CARPETS, RECLINERS, WATCHES, ESCAPING, GOWNING



NOT JUST TRAVEL PURCHASES.



Credit approval required. Offered by Capital One Bank (USA), N.A. © 2016 Capital One

WATER COLLECTIVE

By Nina Strochlic

From India to Bolivia, it was always the women who knew exactly how much water their family needed.

When photographer Ashley Gilbertson sat down in households across six countries to document water access for UNICEF, he'd ask them to tally their daily usage. Then he'd display the total amount used in plastic containers filled from the local source.

Although it was wives and daughters who gathered, purified, cooked, and cleaned with the water, their husbands or fathers answered first. "The men would often have no idea how difficult it was to get the water or how much water was being used," he recalls. "I'd say, 'I think we should talk to your wife,' and she'd start laughing."

The inequality of the chore shocked Gilbertson. Some women he met walked for miles to reach the nearest source. Every day, women and children around the world spend a collective 125 million hours gathering water, according to Water.org.

"Water is a very gendered subject," says Lesley Pories, the institutional partnerships manager at Water.org. "In a society where water comes only at certain times of a day, one's whole day is likely to revolve around water collection." The task, she adds, becomes "an obstacle to paid work or education."

Gilbertson also wanted to photograph water usage in the developed world. When he came home to New York City, he decided it was only fair to use himself as the subject. He and his wife tracked their water usage—the 1,000 daily liters "astonished" them—and posed with the bottles.

"I turn on the tap; water comes out," Gilbertson says. "When you work with people who have to collect that water, you really feel the value of that resource. You *actually* feel it: It's really heavy to carry."



BY THE NUMBERS

200

Liters used daily by the Masaeed family – plus 7,800 additional liters for its 700 sheep – in **Jordan**, top left

1,000

Liters used daily by the Gilbertson family in **New York City**, bottom left



220

Liters used daily by the Sarker family in **India**, top right

60

Liters used daily by the Mahamadou family in **Niger**, bottom right

[NATGEO.COM/PHOTOGRAPHY](https://www.natgeo.com/photography)
Photographer Ashley Gilbertson also documented water usage by families in Bolivia, Malawi, and Myanmar. See more of his work on *National Geographic's* website.



A WATERY SHRINE

By Nina Storchlic

High in the Himalaya, a desert is turning green.

Climate change in the Indian region of Ladakh has shrunk glaciers and made rainfall and temperatures unpredictable. Water is needed to irrigate the fields of barley, apples, and other crops in spring, but the glacial melt doesn't arrive until summer. To spare farmers a barren yield, engineer Sonam Wangchuk has invented a way to bring the glaciers to the people.

In 2015, with \$125,000 raised on a crowdfunding site, Wangchuk built a 64-foot-tall "ice stupa"—an artificial glacier made by piping mountain streams into a Ladakhi village. The water spouts geyser-like from a vertical pipe, freezing into a cone of ice shaped like a Buddhist shrine. It's designed to stay frozen until the spring sun warms the fields.

Sure enough, Wangchuk's prototype began to melt in April, watering a field of newly planted poplar trees. By June, when the regular glacial melt began to flow, the ice stupa was mostly gone.

Now Wangchuk is laying a pipeline to build 50 more ice stupas. Each will

supply 10 million liters of water a year and irrigate 25 acres of land.

Word of his project has reached mountaintops across the world. Last year he built Europe's first ice stupa, in the Swiss Alps, and this year he'll work on refreezing a glacial lake in India to halt flash floods.

The inventor—whose past projects include solar-powered buildings and efficient cookstoves—won a Rolex Award for Enterprise in 2016. He is using the winnings to establish a pan-Himalayan research university that will address the region's environmental concerns.

"The water shortage is a huge problem," said Tsering Spalzes, a local farmer, in a video for the crowdfunding campaign. "In the future our children will find it impossible to continue farming."

Wangchuk hopes that if locals adapt now, their descendants won't become climate refugees. "We in the mountains are minorities, not just ethnically but climate-wise," he says. "Things that work in New York or New Delhi do not work in the mountains. We have to find our own solutions for our problems."

National Geographic produced this article as part of a partnership with the Rolex Awards for Enterprise.



To mitigate the impact of climate change on populations in the Himalaya, engineer Sonam Wangchuk is building ice stupas like the one seen above.

Help end the global water crisis.



1 Limited Edition Chalice = 5 Years Clean Water

Water is essential to the lives we live, and an essential part of our heritage of making Stella Artois. It's not something we take for granted. Every day, women in the developing world spend millions of hours collecting water. Imagine what they could do if they didn't have to.

Learn more at BuyALadyADrink.com

StellaArtois.com
ENJOY RESPONSIBLY

© 2016 Anheuser-Busch InBev S.A., Stella Artois® Beer, Imported by Import Brands Alliance, St. Louis, MO



Be Legacy

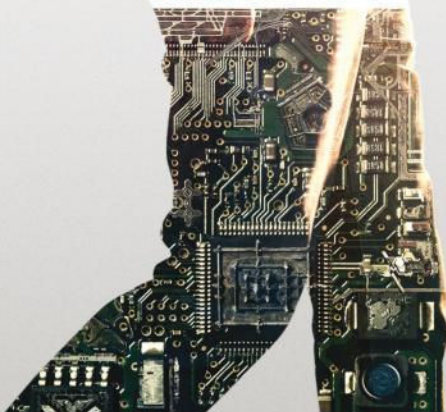
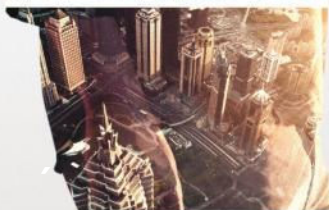


JASON SILVA TRACES THE INNOVATIONS THAT MADE THE WORLD MODERN



ORIGINS:

THE JOURNEY OF HUMANKIND



MONDAYS 9/8c PREMIERES MARCH 6
NEW SERIES | natgeotv.com/origins

 NATIONAL
GEOGRAPHIC

WHEN SEX IS SO RIGHT (OR LEFT)

By Patricia Edmonds

The fish's eyes are ideally suited to helping it thrive and propagate. The fish's loins, on the other hand, are a somewhat trickier fit (literally) for that purpose.

Anableps anableps is commonly called a four-eyed fish, but it actually has only two. They look like four because a horizontal band of tissue splits the eye into two lobes, each with its own pupil and separate vision. Swimming near the surface as it typically does, the fish can see in and out of water simultaneously.

"It's pretty awesome how they can differentiate a predator under and above the water at the same time and process all those images to know which way to go," says Erik Kalen, assistant curator of aquatics at the Oklahoma City Zoo. This almost certainly gives the species an evolutionary advantage, he says.

But that trait isn't *A. anableps*'s only

anatomical quirk. The female's genital opening and the male's sex organ—a pipelike modified fin called a gonopodium—are turned to the right on some fish and to the left on others. This means that a righty male is built to copulate only with a lefty female, and vice versa—which statistically halves the chances of finding a compatible mate. "I can't tell you any advantage to that," Kalen says.

At his zoo's four-eyed-fish exhibit, he says, "it's mass pandemonium when we get into breeding season." Keepers monitor "which males are left-erect and which are right-erect and who's breeding with who." Kalen has sometimes seen a male "struggle extremely hard to go the other way" and mate with a same-sided female, "but I'm not sure it's successful." That could become clear in about 12 weeks, the species' typical gestation period.

FOUR-EYED FISH

HABITAT/RANGE

Fresh or brackish waters on the Atlantic coast of Central, South America

CONSERVATION STATUS

Not yet assessed for the IUCN Red List

OTHER FACTS

Only three species in *A. anableps*'s family have two-lobed eyes.



PHOTOARK
JOEL SARTORE

The male (below left) and female four-eyed fish were photographed at the Oklahoma City Zoo.

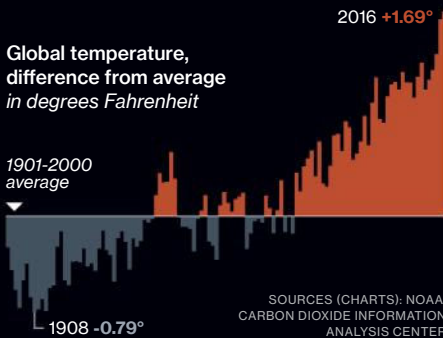


Carbon dioxide
measured on October 24, 2014
in parts per million

390 405

NASA GODDARD MODELING
AND ASSIMILATION
OFFICE (GMAO)

Climate



1 THE WORLD IS WARMING.

The heat in 2016 broke the historic record set in 2015, which broke the one from 2014. Last year's average global surface temperature, compiled from measurements made by thousands of weather stations, buoys, and ships, was 1.69 degrees Fahrenheit warmer than the 20th-century average. Satellites probing the atmosphere also have documented a clear warming trend.

Carbon dioxide on Earth

A NASA satellite has been mapping the changing amounts of carbon dioxide in Earth's atmosphere. In this image derived from data collected in October 2014, swirls of CO₂ emitted by burning fossil fuels in the Northern Hemisphere are clearly visible.

7 THINGS YOU NEED TO KNOW

Change

We need energy—food, fuel, electricity—to lead modern lives. Billions of people need more of it. But how we get energy is changing the Earth in ways that threaten us all. Can we find a better way? Climate change isn't a hoax or a scientific conspiracy, it's a grand challenge. Here are the facts.

Average atmospheric carbon dioxide in parts per million

284
1832

300
1911

350
1987

400
2016

In 2016 annual average CO₂ concentrations exceeded the threshold of 400 parts per million.

2 IT'S BECAUSE OF US.

El Niño added to last year's record by temporarily releasing heat from the Pacific. But no natural cause explains the half-century warming trend. The sun's output cycles up and down every 11 years; volcanic eruptions sporadically cool the planet. Meanwhile human-emitted greenhouse gases form a steadily thickening blanket that traps heat at Earth's surface.

3 WE'RE SURE.

More than nine out of 10 climate scientists agree: Carbon emissions cause global warming. We've known about the greenhouse effect since the 1800s. Swedish physicist Svante Arrhenius even predicted in 1896 that carbon dioxide from coal burning would warm the planet. He saw it as a good thing—and just how bad it will be is debatable. But it's real, and it's dangerous.

Ice Is Melting Fast.

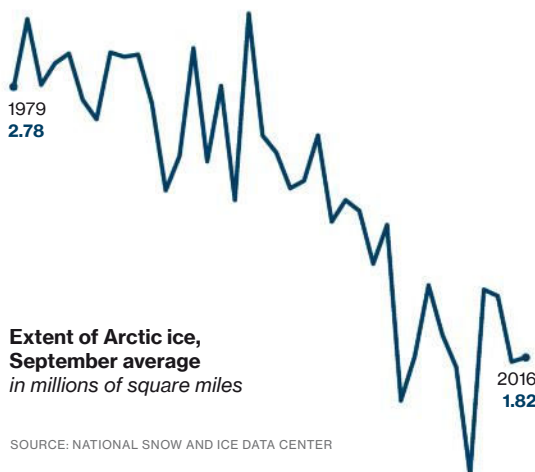
LAST SUMMER the *Crystal Serenity*, a large cruise ship, sailed through the ice-free Northwest Passage. Days after it passed, researchers off King William Island found the long-lost wreck of H.M.S. *Terror*, of Britain's Franklin expedition—which had gotten trapped in the ice in 1846 while searching for the passage. The Arctic has warmed dramatically, and its ice cover has thinned and shrunk (graph, below). That loss speeds the warming, as sunlight is absorbed by dark ocean instead of reflected into space by ice.

Melting sea ice doesn't raise sea level—it's already in the water—but melting land ice does. Mountain glaciers are in global retreat. The total sea level rise of eight or nine inches since 1900 has contributed to a sharp increase in flooding along coasts. During Superstorm Sandy, for example, floods and winds caused \$68 billion in damage on the U.S. East Coast.

The big threat is the ice sheets covering Greenland and Antarctica. They hold enough ice to raise seas more than 200 feet—and they're losing it. When Earth was just a bit warmer, 125,000 years ago, they seem to have lost a lot: Sea levels were 20 to 30 feet higher. Such a rise today would swamp coastal cities.

DWINDLING ARCTIC ICE

The Arctic sea surface freezes each winter, but an increasing part of it melts again in the summer. The area that's still ice-covered in September has declined sharply.



SOURCE: NATIONAL SNOW AND ICE DATA CENTER

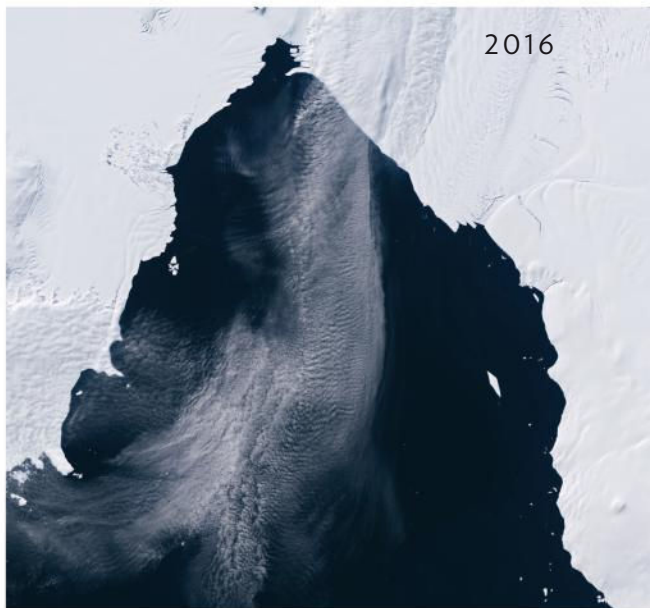


HOW FAST CAN ICE SHEETS FAIL?

A red-suited researcher explores blue pools of meltwater on the Greenland ice sheet (above); since 2002 it has lost an average of 287 billion metric tons of ice a year, according to NASA satellites. Antarctica is losing less, but it's vulnerable: Much of the West Antarctic ice sheet sits on the seabed, and the floating ice shelves that buttress it are eroding in a warmer ocean—as the calving of a 44-square-mile iceberg into Pine Island Bay illustrates (right). A glacial collapse that would raise sea level several feet could take centuries. Or maybe just decades.



NICK COBBING



MIKE TAYLOR, NASA/USGS LANDSAT 8 IMAGES

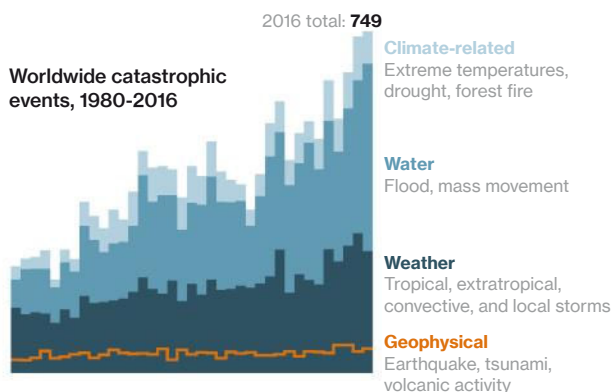
Weather Is Getting Intense.

IN THE CRAPSHOOT that is our weather, climate change loads the dice. It doesn't cause a particular drought or storm, but it makes such events more or less likely—and in the case of heat waves, a lot more likely. The extraordinary heat wave that killed some 70,000 people in Europe in 2003 should have been a once-in-500-years event; at the current level of global warming, it has become a once-in-40-years event, according to a study published last year. In Paris alone, that analysis found, climate change caused 506 excess deaths in 2003. If it continues unchecked, another recent study said, by late this century people living along the Persian Gulf may face many days so hot that it will be unsafe to go outside.

It's not just the heat: Global warming adds moisture to the air, removing it from land and ocean. Where rain is lacking, it makes the drought worse. When rain or snow falls, it's more likely to be extreme; think of the 2016 floods in Paris or Houston. How climate change affects hurricanes and other tropical cyclones is less certain. But by heating the ocean—the storms' energy source—it's likely to make them more intense, if less frequent.

UNNATURAL DISASTERS

Globally, numbers of geologic disasters such as earthquakes are holding steady, while disasters involving parts of the Earth affected by climate change are on the rise.



SOURCE: MUNICH RE NATCATSERVICE



THE CHANGES MATTER

The Syrian civil war—which has forced millions from the country and killed hundreds of thousands, including the boy above—was ignited in part by a historic drought that drove farmers into cities. Climate change more than doubled the odds of such a drought, a 2015 study says. It also helped temporarily dry up Lake Poopó (far right), Bolivia's second largest lake until sapped by drought and water diversion. In other spots, like New York City, more water vapor in the air causes heavier snowfalls—but snow also is melting sooner in spring.



ABD DOUMANY, AFP/GETTY IMAGES



GARY HERSHORN, CORBIS VIA GETTY IMAGES



JOSH HANER, NEW YORK TIMES/REDUX

Wildlife Is Already Hurting.

CLIMATE CHANGE SPELLS TROUBLE for far more than just the Arctic's iconic predator, the polar bear. In 2016 scientists announced that the last Bramble Cay melomys, a ratlike rodent found on one low-lying island in Australia's Torres Strait, had vanished, the victim of forces including rising seas. It's being called the first documented case of a mammal being driven to extinction by climate change. More will surely follow (figures, below).

Rising temperatures are depressing some plant and animal populations, driving species toward the poles, shifting migrations and behavior. Populations of Adélie penguins on the Antarctic Peninsula have plummeted. An Arctic shorebird called the red knot is getting smaller. Ice loss is forcing walruses by the thousands onto land in Alaska. Entire regions are being transformed: Alpine ecosystems from the Rockies to the Swiss Alps are being squeezed off mountaintops. The exceptional ocean warmth of the past few years has triggered coral bleaching and die-offs at reefs around the world.

There will be winners. For now, humpback whales are thriving in newly ice-free waters off Antarctica. Sea urchins too are proving to be resilient. But climate change isn't the only threat that spreading human populations impose on other species; we're also fragmenting and destroying natural habitats. Some species will adapt to the jarring changes in their world—but how many, and for how long?

47%

of 976 species surveyed in a 2016 study had vanished from areas they'd previously occupied on the warm edge of their range. This was true across a variety of habitats and suggests they'd been unable to adapt to the changes in climate. Animals were somewhat more likely than plants to have suffered "local extinction."

1 in 6

species risks global extinction if the climate warms by nearly 8°F. That could happen by 2100 if we don't cut emissions, according to a 2015 study. Biologically rich regions such as South America and New Zealand would be hardest hit, as land features would block species from moving to keep pace with changing climates.

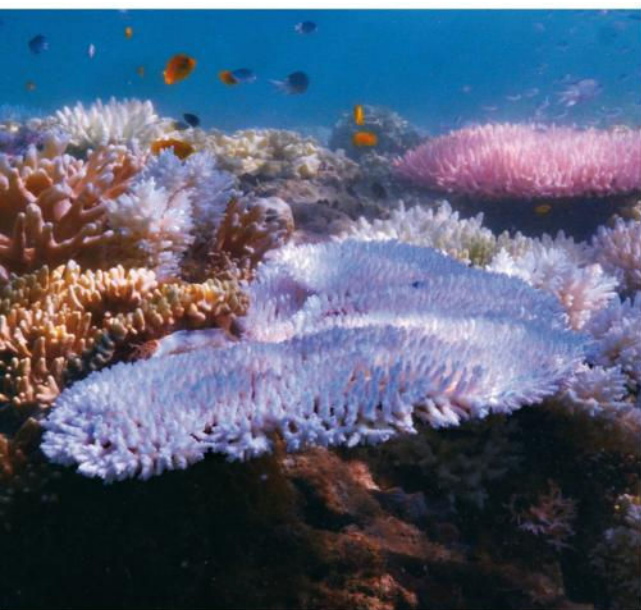


UNNATURAL SELECTION

A polar bear swims past melting sea ice outside Nauyasat, an Inuit hunting village in Nunavut Territory, Canada. A 2017 U.S. government report says greenhouse gas emissions are the top reason polar bears will likely be gone from much of their range by 2050. Meanwhile, the Great Barrier Reef experienced its largest recorded coral die-off in 2016. Prolonged bleaching killed about 67 percent of corals in one 430-mile stretch. Between March 21 (right) and May 15 (far right), warm water decimated coral colonies off Lizard Island.



PAUL SOUDERS



JEFF ORLOWSKI, EXPOSURE LABS, FROM *CHASING CORAL*

We Can Do Something About It.

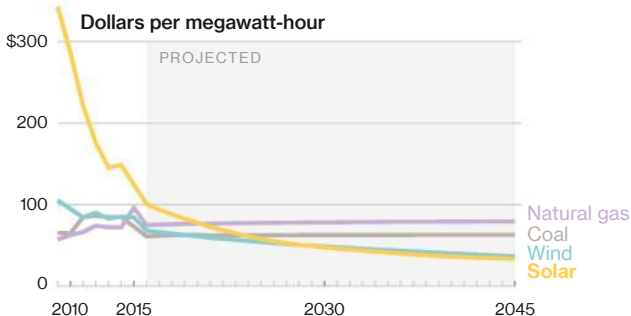
FREE MARKETS are often lauded for their efficient results. In this connected age, there's something like a free market of ideas. So ask yourself: If climate change weren't a serious danger, would 195 countries have signed the Paris Agreement, pledging to try to keep the warming below 2°C (3.6°F)?

Though shadowed by the new U.S. administration's threat to withdraw from it, the agreement stands as one hopeful sign. The graph below shows another: The cost of solar energy is plummeting. Even without a carbon tax—the most efficient way to wean an economy off fossil fuels—renewables soon may be cheaper sources of electricity. Worldwide they accounted for more than half the new generating capacity in 2015. In the U.S., solar now employs more people than coal, oil, and gas combined.

The switch from fossil fuels is still just beginning. Every little bit matters: Every ton of CO₂ we emit melts 32 square feet of Arctic ice, according to a 2016 study, which means the average American melts 525 square feet a year. Every energy-saving building, retired gas-guzzler, and acre of preserved forest helps. But none of it will help much if the world doesn't switch to a carbon-free energy supply soon.

CLEAN ENERGY, EVER CHEAPER

As sales of solar panels have exploded, the cost has plummeted faster than experts predicted—a result of technological progress as well as economies of scale.



SOURCE: BLOOMBERG NEW ENERGY FINANCE

ONE PROBLEM, MANY SOLUTIONS

The 300-megawatt wind farm near Tarfaya, Morocco (above), is one of the largest in Africa—which has a chance to leapfrog part of the carbon era. Wind and solar use a lot of land, though, so Japan is putting solar panels on ponds (right) as well as rooftops. Nuclear power uses less land and runs 24/7, but has safety and waste concerns. Two new reactors being built at the Vogtle plant in Georgia (far right) are among the first in the U.S. since the 1979 Three Mile Island accident. The photo shows the containment structure for one reactor.





SIEMENS AG



JAMEY STILLINGS



GEORGIA POWER COMPANY

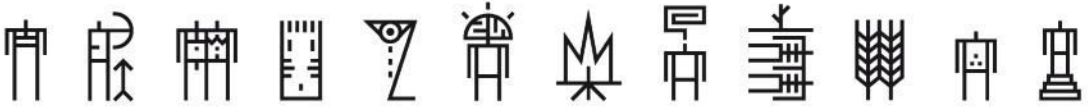


LIKE ANY OTHER SPECIES, WE
ARE THE PRODUCT OF MILLIONS
OF YEARS OF EVOLUTION.
NOW WE'RE TAKING MATTERS
INTO OUR OWN HANDS.

BY **D. T. MAX**

ILLUSTRATIONS BY **OWEN FREEMAN**





WHEN I MET THE CYBORG NEIL HARBISSEON, IN BARCELONA, HE LOOKED LIKE ANY LOCAL HIPSTER, EXCEPT FOR THE BLACK ANTENNA ARCHING IMPRESSIVELY FROM THE BACK OF HIS SKULL OVER HIS MOP OF BLOND HAIR.

It was December, and Harbisson, 34, was wearing a zippered gray shirt under a black peacoat, with narrow gray pants. Born in Belfast and raised in Spain, he has a rare condition called achromatopsia; he cannot perceive color. His antenna, which ends in a fiber-optic sensor that hovers right above his eyes, has changed that.

Harbisson never felt that living in a black-and-white world was a disability. “I see longer distances. Also I memorize shapes more easily because color doesn’t distract me,” he told me, in his careful, neutral English.

But he was deeply curious about what things looked like in color too. Having trained as a musician, he had the idea in his late teens of trying to discover color through sound. After some low-tech false starts, in his early 20s he found a surgeon (who remains anonymous) who was willing to implant a device, a cybernetic enhancement to his biological self.

The fiber-optic sensor picks up the colors in front of him, and a microchip implanted in his skull converts their frequencies into vibrations on the back of his head. Those become sound frequencies, turning his skull into a sort of third ear. He correctly identified my blazer as blue and, pointing his antenna at his friend Moon Ribas, a cyborg artist and dancer, said her jacket was yellow—it was actually mustard yellow, but as he explained, in Catalonia “we didn’t grow up with mustard.”

When I asked Harbisson how the doctor had attached the device, he cheerfully parted the hair at the back of his head to show me the antenna’s point of entry. The pinkish flesh was pressed down by a rectangular plate



with two anchors. A connected implant held the vibrating microchip, and another implant was a Bluetooth communication hub, so friends could send him colors through his smartphone.

The antenna has been a revelation for Harbisson. The world is more exhilarating for him now. Over time, he said, the input has begun to feel neither like sight nor hearing but a sixth sense.

The most intriguing part of the antenna, though, is that it gives him an ability the rest of us don't have. He looked at the lamps on the roof deck and sensed that the infrared lights that activate them were off. He glanced at the planters and could "see" the ultraviolet markings that show where nectar is located at the centers of the flowers. He has not just matched ordinary human skills; he has exceeded them.

He is, then, a first step toward the goal that visionary futurists have always had, an early example of what Ray Kurzweil in his well-known book *The Singularity Is Near* calls "the vast expansion of human potential." Harbisson hadn't particularly meant to jump-start Kurzweil's dream—his vision of the future is more sylvan than silicon. But since he became the world's first official cyborg (he persuaded the British government to let him wear the antenna in his passport photo, arguing that it was not an electronic device, but an extension of his brain), he has also become a proselytizer. Ribas soon followed him into what is sometimes called transhumanism by having a seismic monitor in her phone connect to a vibrating magnet buried in her upper arm. She gets real-time reports of earthquakes,

EVOLUTION OF HUMAN TRAITS

Icons (above), which appear throughout this story, depict cultural and biological milestones in human evolution.




12,500 YEARS AGO

EVOLVED TO LIVE AT HIGH ALTITUDES

Until recently it was thought that our species had stopped evolving far in the past. Our ability to peer inside the human genome has shown that in fact our biology continues to change to suit particular environments. Most of us feel breathless in high mountain air because our lungs must work harder to capture the reduced level of oxygen there. But Andeans have a genetically determined trait that allows their hemoglobin to bind more oxygen. Tibetan and Ethiopian populations independently adapted to their high elevations, showing that natural selection can take us on different paths to reach the same outcome: survival.





A night desert landscape with a starry sky and a tent. The sky is a deep blue, filled with numerous small white stars. The foreground shows a dark, sandy desert with a simple tent structure on the left. The horizon is a dark silhouette of low hills or mountains.

8,000 YEARS AGO

ADAPTED TO A DESERT CLIMATE

The desert presented an evolutionary challenge for the inhabitants of Sahul, the continent that once united Australia, New Guinea, and Tasmania. After the ancestors of modern Aboriginals made the crossing to Sahul, around 50,000 years ago, they developed adaptations that allowed them to survive below-freezing temperatures at night and days often exceeding 100 degrees Fahrenheit. A genetic mutation in a metabolism-regulating hormone provides this survival advantage, especially for infants, by modulating the excess energy that's produced when body temperature rises.



Bipedalism

Our early ancestors may have adapted to walking on two legs as an efficient way to travel long distances, possibly to find new kinds of food.



Making tools

One of our first cultural adaptations expanded our diets. With better nourishment, we could develop bigger, more complex brains.



Lack of fur

Early humans may have developed skin without thick fur in order to keep cool on the savanna and make body parasites easier to find.

allowing her to feel connected to the motions of the Earth and interpret them through dance. “I guess I got jealous,” she says.

“We will transcend all of the limitations of our biology,” Kurzweil promised. “That is what it means to be human—to extend who we are.”

Clearly Harbisson’s antenna is merely a beginning. But are we on the way to redefining how we evolve? Does evolution now mean not just the slow grind of natural selection spreading desirable genes, but also everything that we can do to amplify our powers and the powers of the things we make—a union of genes, culture, and technology? And if so, where is it taking us?

CONVENTIONAL EVOLUTION IS ALIVE AND WELL in our species. Not long ago we knew the makeup of only a handful of the roughly 20,000 protein-encoding genes in our cells; today we know the function of about 12,000. But genes are only a tiny percentage of the DNA in our genome. More discoveries are certain to come—and quickly. From this trove of genetic information, researchers have already identified dozens of examples of relatively recent evolution. Anatomically modern humans migrated from Africa sometime between 80,000 and 50,000 years ago. Our original genetic inheritance was appropriate for the warm climates where we first evolved from early hominins to humans, from knuckle-walkers to hunters and gatherers. But a lot has happened since that time, as humans have expanded around the world and the demands posed by new challenges have altered our genetic makeup.

Recent, real-life examples of this process abound. Australian Aboriginals living in desert climates have a genetic variant, developed in the past 10,000 years, that allows them to adjust more easily to extreme high temperatures. Prehistorically, most humans, like other mammals, could digest milk only in infancy—we had genes that turned off the production of the milk-digesting enzyme when we were weaned. But around 9,000 years ago, some humans began to herd animals rather than just hunt them. These herders developed genetic alterations that allowed them to continue making the relevant enzyme for their whole lives, a handy adaptation when their livestock were producing a vitamin-rich protein.

In a recent article in the *Scientist*, John Hawks, a paleoanthropologist at the University of Wisconsin–Madison, wrote how impressed he was at the speed with which the gene was disseminated: “up to 10 percent per generation. Its advantage was enormous, perhaps the strongest known for any recent human trait.”

Similarly, the ancestors of all non-Africans came out of Africa with dark skin. Indeed even 10,000 years ago, according to researchers, European and African skin looked much the same. But over time humans in darker northern climates evolved less heavily pigmented skin, which helped absorb the sun’s ultraviolet rays and synthesize vitamin D more efficiently. The Inuit of Greenland have an adaptation that helps them digest the omega-3 fatty acids in fish far better than the rest of us. An indigenous population near the Argentine town of San Antonio de los Cobres has evolved to be able to drink

the high levels of arsenic that have occurred naturally in their groundwater.

Evolution is relentless; when the chance of survival can be increased, it finds a way to make a change—sometimes several different ways. Some Middle Eastern populations have a genetic variation that’s different from the one northern Europeans have to protect them from lactose intolerance. And there are a half dozen distinct genetic adaptations that protect Africans against malaria (one has the significant drawback of also causing sickle-cell anemia, if the altered form of the gene is inherited from both parents). In the past 50 years researchers have uncovered a variety of adaptations in Andeans, Ethiopians, and Tibetans that allow them to breathe more efficiently at high altitudes. Andean populations retain higher levels of oxygen in their blood. Among Tibetans there is evidence that a gene was introduced through interbreeding with Denisovans, a mysterious branch of the human lineage that died out tens of thousands of years ago. All these adaptations give indigenous people living at high altitudes an advantage over the woozy visitor gasping for oxygen in the mountain air.

EARLY IN *ORIGIN OF SPECIES*, Charles Darwin comes out fighting: “Natural Selection, as we shall hereafter see, is a power incessantly ready for action, and is immeasurably superior to man’s feeble efforts, as the works of Nature are to those of Art.” The book was published in 1859. Is what was true then still true today? Was it true even in Darwin’s lifetime? Biological evolution may be implacable, and indeed more skillful than the genetic evolution humans can effect with crossbreeding in plants and animals, but how important is it, measured against the adaptations we can devise with our brains? To paraphrase the paleoanthropologist Milford Wolpoff, if you can ride a horse, does it matter if you can run fast?

In our world now, the primary mover for reproductive success—and thus evolutionary change—is culture, and its weaponized cousin, technology. That’s because evolution is no match for the speed and variety of modern life. Despite what evolution has accomplished in the recent past, think of how poorly adapted we are to our computer screens and 24-hour schedules, our salty bags of corn chips and pathogen-depleted environments. Why are our internal clocks so rigid? Why can’t our seemingly useless appendix, which may have once helped us digest grass, shift to break down sugars instead? If human genetics were a tech company, it would have gone bankrupt when steam power came along. Its business plan calls for a trait to appear by chance and then spread by sexual reproduction.

This works nimbly in mice, which can produce a new litter in three weeks, but humans go about things more slowly, producing a new generation only every 25 to 35 years or so. At this rate, it can take thousands of years for an advantageous trait to be spread throughout a population. Given genetic evolution’s cumbersome protocols, it’s no surprise technology has superseded it. Technology now does much of the same work and does it far faster, bolstering our physical skills, deepening our intellectual range, and allowing us to expand into new and more challenging environments.

“People get hung up on Darwin and DNA,” says George Church,



Blushing

The embarrassment and uncomfortable tingling of a blush can signal remorse and elicit forgiveness from peers in a social group.



Tears of emotion

Crying shows vulnerability and increases the chances of receiving help, which, in turn, strengthens social bonds in a group.



Bigger brains

As we gathered into larger social groups, bigger brains developed along with more complex communication and problem-solving.



An illustration of a person wearing a yellow hazmat suit and hood, holding a black bag. They are standing in a field of tall green grass, with a large, intricate web of white spider webs draped over the scene. In the background, there are several houses and trees under a dark, overcast sky. The overall mood is mysterious and ominous.

PRESENT DAY

TECHNOLOGY VERSUS NATURAL SELECTION

We big-brained humans have done much to neutralize the power of natural selection. With our tools, medicine, and other cultural innovations, we have started a potentially deadly race—one we could lose to a highly evolved superbug. Given the speed with which we can spread disease around the globe, “we are in a new pandemic era and must take action now to stop it,” says Kevin Olival, a disease ecologist at EcoHealth Alliance. Shifts brought about by habitat destruction and climate change are also bringing more people into contact with pathogens previously isolated from human hosts.

PRESENT DAY AND NEAR FUTURE

DO-IT-YOURSELF EVOLUTION

Pairing in vitro fertilization with another process allows us to test embryos for mutations that could lead to serious medical conditions. Now we're developing powerful new gene-editing tools that could bring about human-directed evolution. Most research has been on other organisms—for instance, attempting to change a mosquito genome so that the insect cannot transmit Zika or malaria. We could harness the same techniques to “design” our babies—simply to choose a preferred hair or eye color. But should we? “There’s definitely a dark side,” says bioethicist Linda MacDonald Glenn, “but I do think humanity-plus is inevitable. We are, by our nature, tinkerers.”







Mastery of fire

With fire we could cook food and vary our diet, defend against predators, and socialize more—which may have refined language.



Beginnings of art

Artistic expression and the use of symbols helped lay the groundwork for extended social networks and later for civilizations.



Ritual burial

The evolution of symbolic behaviors to accompany death signaled self-awareness and thoughts about a possible afterlife.

a molecular engineer with a joint appointment at Harvard and MIT. “But most of the selection today is occurring in culture and language, computers and clothing. In the old days, in the DNA days, if you had a pretty cool mutation, it might spread in the human race in a hundred thousand years. Today if you have a new cell phone or transformative manufacturing process, it could spread in a week.”

To be sure, the picture is more complicated. As the cyberpunk writer William Gibson has pointed out: “The future is already here. It’s just not evenly distributed yet.” Some of us live in Church’s world of jet travel and intersociety marriage, of molecular medicine and gene therapy, and seem to be heading toward a time when our original genetic makeup is simply a draft to be corrected. But outside the most developed parts of the world, DNA is still often destiny.

Not all trends are irreversible, however. There are scenarios under which natural selection would return to center stage for the rest of us too. If there were a global disease outbreak, for instance, along the lines of the great influenza pandemic of 1918, those with a resistance to the pathogen (because of a robust immune system or protective bacteria that could render such a pathogen innocuous) would have a huge evolutionary advantage, and their genes would carry forward into subsequent generations while the rest of us died out.

We have medicines today to combat many infectious diseases, but virulent bacteria have recently evolved that do not respond to antibiotics. Jet travel can send an infectious agent around the world in a day or two. Climate change might prevent cold temperatures from killing off whatever animal carried it, as winter may have once killed the fleas that harbored the plague.

Elodie Ghedin, a microbiologist at New York University, says, “I don’t know why people aren’t more scared.” She and I discussed the example of AIDS, which has killed 35 million people worldwide, a death toll roughly equal to that of the 1918 pandemic. It turns out that a small percentage of people—no more than one percent—have a mutation of the gene that alters the behavior of a cellular protein that HIV, the virus that causes AIDS, must latch on to, making it nearly impossible for them to become infected. If you live in New York City’s Greenwich Village, with access to the best antiviral drugs, this may not decide if you live or die. But if you are HIV-positive in rural Africa, it very well might.

There are many more scenarios by which genes could return to center stage in the human drama. Chris Impey, a professor of astronomy at the University of Arizona and an expert on space travel, foresees a permanent Martian settlement within our grandchildren’s lifetimes, stocked by the 100 or 150 people necessary to make a genetically viable community. A first, smaller wave of settlement he regards as even closer at hand: “When Elon Musk is glue-sniffing, he might say 10 to 15 years,” Impey says, “but 30 to 40 doesn’t seem that radical.” Once the settlement is established, he adds, “you’re going to accelerate natural evolutionary processes. You’re going to have a very artificial and physically difficult environment that’s going to shape the framework of the travelers or colonists in a

fairly aggressive way.” The optimal Earthling turned Martian, he says, would be long and slender, because gravity on the red planet has about one-third the force of Earth’s. Over generations, eyelashes and body hair might fade away in an environment where people never come directly into contact with dust. Impey predicts—assuming that the Martian humans did not interbreed with terrestrial ones—significant biochemical changes in “tens of generations, physical changes in hundreds of generations.”

ONE HUMAN TRAIT WITH A STRONG genetic component continues to increase in value, even more so as technology grows more dominant. The universal ambition of humanity remains greater intelligence. No other attribute is so desirable; no other so useful, so varied in its applications, here and on any world we can imagine. It was indispensable to our forebears in Africa and will come in handy for our descendants on the planet orbiting the star Proxima Centauri, should we ever get there. Over hundreds of thousands of years, our genes have evolved to devote more and more resources to our brains, but the truth is, we can never be smart enough.

Unlike our forebears, we may soon not need to wait for evolution to fix the problem. In 2013 Nick Bostrom and Carl Shulman, two researchers at the Future of Humanity Institute, at Oxford University, set out to investigate the social impact of enhancing intelligence, in a paper for *Global Policy*. They focused on embryo selection via in vitro fertilization. With IVF, parents can choose which embryo to implant. By their calculations, choosing the “most intelligent embryo” out of any given 10 would increase a baby’s IQ roughly 11.5 points above chance. If a woman were willing to undergo more intensive hormone treatments to produce eggs faster—“expensive and burdensome,” as the study notes with understatement—the value could grow.

The real benefit, though, would be in the compound gain to the recipient’s descendants: After 10 generations, according to Shulman, a descendant might enjoy an IQ as much as 115 points higher than his or her great-great-great-great-great-great-great-great-grandmother’s. As he pointed out to me, such a benefit is built on extremely optimistic assumptions, but at the least the average recipient of this genetic massaging would have the intelligence equal to a genius today. Using embryonic stem cells, which could be converted into sperm or ova in just six months, the paper notes, might yield far faster results. Who wants to wait two centuries to be the scion of a race of geniuses? Shulman also mentioned that the paper omitted one obvious fact: “In 10 generations there will likely be computer programs that outperform even the most enhanced human across the board.”

There’s a more immediate objection to this scenario, though: We don’t yet know enough about the genetic basis for intelligence to select for it. One embryo doesn’t do advanced calculus while another is stuck on whole numbers. Acknowledging the problem, the authors claim that the ability to select for “modest cognitive enhancement” may be only five to 10 years off.



Starch metabolism

Humans with high-starch diets, such as those heavy on rice, have evolved specific genes that help them digest these foods.




Salt retention

Some tropical populations have genes that prevent them from losing too much salt in sweat when exposed to high temperatures.



Short stature

Small bodies in pygmy peoples may result from early reproduction, a response, in turn, to tropical diseases and early death.

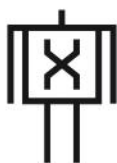


NEAR FUTURE

SCIENCE FICTION BECOMES REALITY

More than 50 years ago two scientists coined the word “cyborg” for an imaginary organism—part human, part machine. It seemed science fiction, but today around 20,000 people have implants that can unlock doors. Neil Harbisson, who can perceive colors only by transforming them into sounds he can hear through an antenna implanted in his head, sees a future vastly improved by widening our senses with such technology. “Night vision,” he says, “would give us the ability to adapt to the environment: design ourselves instead of the planet. Designing the planet is harming it.”





Thrifty genes

Some genes found in tropical islanders aid survival on limited food resources but could lead to obesity in a high-calorie environment.



Thick hair

East Asians evolved thick hair shafts 35,000 years ago, perhaps through sexual selection or as an aid in regulating heat.



Digesting seaweed

In Japan, where a coastal diet dominates, genes in human gut bacteria help the local population extract nutrition from seaweed.

At first glance this would seem improbable. The genetic basis of intelligence is very complex. Intelligence has multiple components, and even individual aspects—computational ability, spatial awareness, analytic reasoning, not to mention empathy—are clearly multigenetic, and all are influenced by environmental factors as well. Stephen Hsu, vice president for research at Michigan State University, who co-founded the Cognitive Genomics Lab at BGI (formerly Beijing Genomics Institute), estimated in a 2014 article that there are roughly 10,000 genetic variants likely to have an influence on intelligence. That may seem intimidating, but he sees the ability to handle that many variants as nearly here—“in the next 10 years,” he writes—and others don’t think you’d need to know all the genes involved to start selecting smarter embryos. “The question isn’t how much we know or don’t know,” Church says. “It’s how much we need to know to make an impact. How much did we need to know about smallpox to make a vaccine?”

If Church and Hsu are right, soon the only thing holding us back will be ourselves. Perhaps we don’t want to practice eugenics on our own natural genomes. Yet will we pause? If so, for how long? A new technology called CRISPR-Cas9 has emerged, developed in part in Church’s lab, that will test the limitations on human curiosity. First tried out in 2013, CRISPR is a procedure to snip out a section of DNA sequence from a gene and put a different one in, quickly and accurately. What used to take researchers years now takes a fraction of the time. (See “DNA Revolution,” in the August 2016 issue of *National Geographic*.)

No technology remotely as powerful has existed before for the manipulation of the human genome. Compare CRISPR and IVF. With IVF you select the embryo you want from the ones nature has provided, but what if none of the embryos in a given set is, for instance, unusually intelligent? Reproduction is a crapshoot. A story, likely apocryphal, illustrates the point: When the dancer Isadora Duncan suggested to the playwright George Bernard Shaw that they have a baby together so it would have her looks and his brains, he is said to have retorted: “But what if it had your brains and my looks?” CRISPR would eliminate that risk. If IVF is ordering off a menu, CRISPR is cooking. In fact, with CRISPR, researchers can insert a new genetic trait directly into the egg or sperm, thus producing, say, not just a single child with Shaw’s intelligence and Duncan’s looks but an endless race of them.

So far many experiments using CRISPR have been done on animals. Church’s lab was able to use the procedure to reengineer pig embryos to make their organs safer for transplant into humans. A colleague of Church’s, Kevin Esvelt at the MIT Media Lab, is working to alter the mouse genome so the animal can no longer host the bacterium that causes Lyme disease. A third researcher, Anthony James of the University of California, Irvine, has inserted genes in the *Anopheles* mosquito that prevent it from carrying the malaria parasite.

Around the same time, however, researchers in China surprised everyone by announcing that they had used CRISPR in nonviable human

embryos to try to fix the genetic defect that causes beta-thalassemia, a potentially fatal blood disorder. Their attempt failed, but moved them closer to finding a way to fix the defect. Meanwhile there is an international moratorium on all therapies for making heritable changes in human genes until they are proved safe and effective. CRISPR is no exception.

WILL SUCH A HALT LAST? No one I spoke to seemed to think so. Some pointed to the history of IVF as a precedent. It was first touted as a medical procedure for otherwise infertile couples. Soon its potential to eradicate devastating genetic diseases was clear. Families with mutations that caused Huntington's or Tay-Sachs diseases used the technique to choose disease-free embryos for the mother to carry to term. Not only was the child-to-be spared much misery, but so were his or her potential offspring. Even if this was playing God in the nursery, it still seemed reasonable to many people. "For this sort of technology to be banned or not used," notes Linda MacDonald Glenn, a bioethicist at California State University, Monterey Bay, "is to suggest that evolution has been benign. That it somehow has been a positive. Oh Lord, it has not been! When you think of the pain and suffering that has come from so many mistakes, it boggles the mind."

As IVF became more familiar, its accepted purpose spread from preventing disease to include sex selection—most notably in Asia, where the desire for sons has been overwhelming, but also in Europe and America, where parents talk about the virtues of "family balancing." Officially, that's as far as the trend toward nonmedical uses has gone. But we are the species that never knows when to stop. "I have had more than one IVF specialist tell me that they can screen for other desirable traits, such as desired eye and hair color," Glenn told me. "It is not advertised, just via word of mouth." In other words, a green-eyed, blond child, if that's your taste, could already be yours for the asking.

CRISPR is a vastly more powerful technology than IVF, with a far greater risk of abuse, including the temptation to try to engineer some sort of genetically perfect race. One of its discoverers, Jennifer Doudna, a professor of chemistry and molecular biology at the University of California, Berkeley, recounted to an interviewer a dream she'd had in which Adolf Hitler came to learn the technique from her, wearing a pig's face. She emailed me recently to say she still hoped the moratorium would last. It would, she wrote, "give our society time to research, understand, and discuss the consequences, both intended and unintended, of changing our own genome."

On the flip side, the potential benefits of applying CRISPR to humans are undeniable. Glenn hopes at least for "thoughtful discussions" first on how the technique will be used. "What becomes the new norm as we try to improve ourselves?" she asks. "Who sets the bar, and what does enhancement mean? You might enhance people to make them smarter, but does smarter equal better or happier? Should we be enhancing morality? And what does that mean?"

Many other scientists don't think everyone will wait to find out; as soon as CRISPR is shown to be safe, ethical questions will recede, just as they



Fat metabolism
Inuit populations have a genetic variant that allows them to digest the fatty foods of their regional diet, like whales and seals.



Arsenic tolerance
Some Argentine populations have adapted to tolerate high levels of arsenic commonly found in the groundwater where they live.

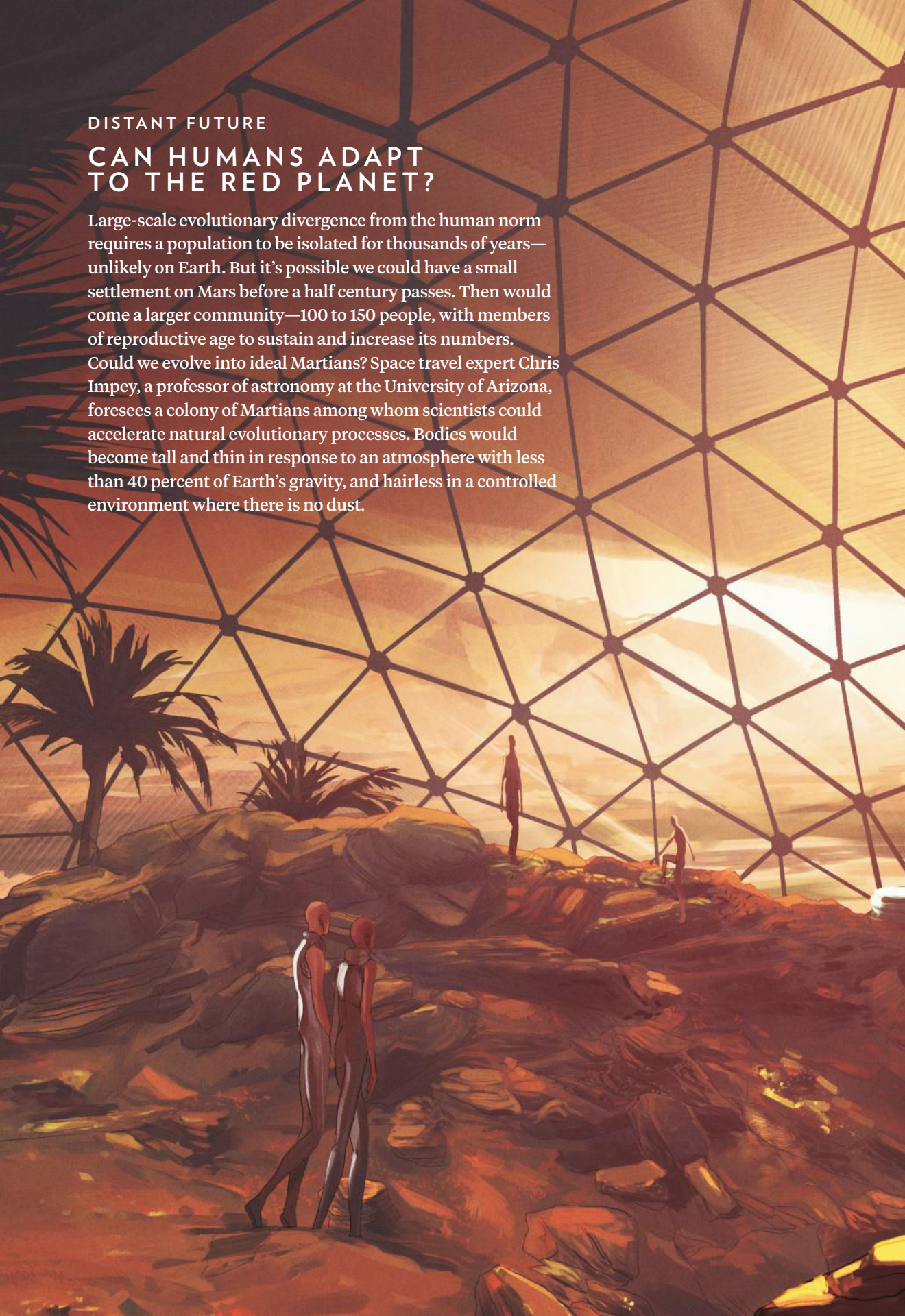


Domestication
Animal and plant domestication, probably spreading hand in hand, led to permanent settlements and later to cities and civilizations.

DISTANT FUTURE

CAN HUMANS ADAPT TO THE RED PLANET?

Large-scale evolutionary divergence from the human norm requires a population to be isolated for thousands of years—unlikely on Earth. But it's possible we could have a small settlement on Mars before a half century passes. Then would come a larger community—100 to 150 people, with members of reproductive age to sustain and increase its numbers. Could we evolve into ideal Martians? Space travel expert Chris Impey, a professor of astronomy at the University of Arizona, foresees a colony of Martians among whom scientists could accelerate natural evolutionary processes. Bodies would become tall and thin in response to an atmosphere with less than 40 percent of Earth's gravity, and hairless in a controlled environment where there is no dust.







Urban resistance

As humans settled in more densely packed communities, they evolved a stronger natural resistance to infectious diseases.



Lactose tolerators

Early groups that domesticated animals, like herders in Europe, the Middle East, and Africa, evolved the ability to digest milk beyond infancy.



Writing

What started as a system for trade and accounting grew into full expressions of complex language as our cities and cultures expanded.

did with IVF. Church thinks this still misses the point: The floodgates are already open to genetic reengineering—CRISPR’s but one more drop in the river. He notes that there are already 2,300 gene therapy trials under way. Last year the CEO of a company called BioViva claimed to have successfully reversed some of the effects of aging in her own body with injections from a gene therapy her company devised. “Certainly,” Church notes, “aging reversal is just as augmentative as anything else we were talking about.” Several gene therapy trials for Alzheimer’s are also in progress. These won’t likely produce any objections, because they are to treat a devastating medical condition, but as Church points out, “whatever drugs work to prevent Alzheimer’s will probably also work for cognitive enhancement, and they will work in adults almost by definition.” In February 2016 the boundary crumbled a bit more when the United Kingdom’s independent fertility regulator gave a research team permission to use CRISPR to explore the mechanisms of miscarriage with human embryos (all embryos used in the experiments will ultimately be destroyed—no pregnancies will result).

Church can’t wait for the next chapter. “DNA was left in the dust by cultural evolution,” he says, “but now it’s catching up.”

OUR BODIES, OUR BRAINS, AND THE MACHINES around us may all one day merge, as Kurzweil predicts, into a single massive communal intelligence. But if there’s one thing natural evolution has shown, it’s that there are many paths to the same goal. We are the animal that tinkers ceaselessly with our own limitations. The evolution of evolution travels multiple parallel roads. Whatever marvelous skills CRISPR might provide us 10 years from now many people want or need now. They follow Neil Harbisson’s example. Instead of going out and conquering technology, they bring it within themselves.

Medicine is always the leading edge in these applications, because using technology to make someone well simplifies complicated moral questions. A hundred thousand Parkinson’s disease sufferers worldwide have implants—so-called brain pacemakers—to control symptoms of their malady. Artificial retinas for some types of blindness and cochlear implants for hearing loss are common. Defense Department money, through the military’s research arm, the Defense Advanced Research Projects Agency (DARPA), funds much of this development. Using such funding, a lab at the University of Southern California’s Center for Neural Engineering is testing chip implants in the brain to recover lost memories. The protocol might one day be applied to Alzheimer’s patients and those who have suffered a stroke or traumatic brain injury. Last year, at the University of Pittsburgh, a subject was able to transmit electrical impulses from his brain, via a computer, to control a robotic arm and even sense what its fingers were touching. That connecting the human brain to a machine would produce a matchless fighter has not been lost on DARPA. “Everything there is dual purpose,” says Annie Jacobsen, whose book *The Pentagon’s Brain* chronicles such efforts. “You have to remember DARPA’s job isn’t to help people. It’s to create ‘vast weapon systems of the future.’”

Human enhancements needn't confer superhuman powers. Hundreds of people have radio-frequency identification (RFID) devices embedded in their bodies that allow them to unlock their doors or log on to their computers without touching anything. One company, Dangerous Things, claims to have sold 10,500 RFID chips, as well as do-it-yourself kits to install them under the skin. The people who buy them call themselves body hackers or grinders.

Kevin Warwick, an emeritus professor of engineering at Reading and Coventry Universities, in England, was the first to have an RFID device implanted in his body, back in 1998. He told me the decision had been a natural emanation of working in a building with computerized locks and automatic sensors for temperature and light: He wanted to be as smart as the structure that housed him. "Being a human was OK," Warwick told a British newspaper in 2002. "I even enjoyed some of it. But being a cyborg has a lot more to offer." Another grinder had an earbud implanted in his ear. He wants to implant a vibrator beneath his pubic bone and connect it via the web to others with similar implants.

It's easy to caricature such things. The practitioners reminded me of the first men who tried to fly, with long arm paddles fringed with feathers. But it was when I asked Harbisson to show me where his antenna entered his skull that I realized something else. I wasn't sure whether the question was appropriate. In Philip K. Dick's novel *Do Androids Dream of Electric Sheep?* (the book that became the movie *Blade Runner*) it's considered rude to ask about the mechanisms powering an android. "Nothing could be more impolite," the narrator opines. But Harbisson was eager to show me how his antenna worked. He reminded me of how happily people show off their new smartphones or fitness trackers. I began to wonder what the difference really was between Harbisson and me—or any of us.

Nielsen reported in 2015 that the average adult over 18 spent roughly 10 hours a day looking at a screen. (By comparison, we spend 17 minutes a day exercising.) I still remember the home phone number of my best friend from childhood, but not the numbers of any of my good friends now. (This is true of seven of 10 people, according to a study published in Britain.) Seven out of 10 Americans take a prescription drug; of these, one in four women in their 40s or 50s takes an antidepressant, though studies show that for some of them anything from therapy to a short walk in the woods can do as much good. Virtual reality headsets are one of the hottest selling gamer toys. Our cars are our feet, our calculators are our minds, and Google is our memory. Our lives now are only partly biological, with no clear split between the organic and the technological, the carbon and the silicon. We may not know yet where we're going, but we've already left where we've been. □

D. T. Max is a *New Yorker* staff writer and author of *The Family That Couldn't Sleep: A Medical Mystery*. Owen Freeman is an illustrator based in Los Angeles. His artwork covers science, history, entertainment, and current events. Artist **Álvaro Valiño**, whose work has appeared in various National Geographic publications, created the icons featured in this story.



Skin color

Light skin (higher latitudes) increases absorption of ultraviolet light and production of vitamin D. Dark skin (lower latitudes) offers UV protection.



Blood mutations

Different populations exhibit various blood mutations; in a tropical climate, sickle-shaped cells can bestow resistance to malaria.



Tall Europeans

Tall stature among northern Europeans could be another sexually selected trait, reinforced by its allure for the opposite sex.

| DISPATCHES | PAKISTAN

Home on the Range

In a remote, mountainous region of Pakistan, technology and education redefine village traditions.

Above the village of Pasu, a teenager checks his smartphone. Locals here are Ismaili, followers of a moderate branch of Islam whose imam is the Aga Khan. Writing on the slope recalls the Aga Khan's 1987 visit to the area.





WEL COME TO PAFI
OUR BELOVED 18 NOV
HAZIR IMAM 1987

In 1999, when I first trekked in the Karakoram Mountains of Pakistan, the area drew tens of thousands of tourists a year. I was instantly drawn to one region, Gojal.

Nestled below peaks near the Chinese and Afghan borders, Gojal's villages are home to some 20,000 people: Ismailis, followers of a moderate branch of Islam led by the Aga Khan, who are also Wakhis, members of an ethnic group with Persian origins. Since "the terrible September 11th attacks," said local tour guide Karim Jan, few tourists have come. Like others in Pakistan, Gojalis have suffered from the association of their nation with terrorism and violence, and many feel helpless to change it.

I've visited Gojal repeatedly over the years, including last summer with my family, and what I've seen belies that reputation. I hope my photos and words can add nuance to people's understanding of this place.

Surrounded by glaciers and unscaled mountains, the Ismailis had long lived in relative isolation. But new inventions and advances have let the outside world in. On each visit I've noticed more changes. The improved Karakoram Highway, once passable only in jeeps and 4x4s, now carries visitors from southern Pakistani cities. The villages' young men and women go to those cities to get educated, as their imam urges. They come back for summer holidays dressed in hip fashions.

Last year when I visited a group of young men in the village of Pasu, some wore designer T-shirts, jeans, styled beards, and ponytails; others wore traditional white pants and long shirts. One of them, Sajid Alvi, spoke excitedly about leaving soon for Sweden, where he had a grant to pursue a Ph.D.: "I will work on developing new aerospace materials—real geeky stuff!" But it's not only the young men finding opportunities beyond the village, Alvi said. Pointing to young women playing volleyball nearby, he said, "They are all going to school, and most of them speak at least four languages." He quoted a local saying: If a family can't afford to educate both its son and its daughter, "give the education to the girl."

Esar Ali agreed that changes in village life "come a lot from our education...But they also come from this," he said, pointing to his phone. Smartphones and mobile data networks have affected daily life and old traditions—courtship, for one. Recalling where he first met his future wife, Shayna, Ali noted, "There is a decent 2G reception there." Until recently parents arranged marriages, and couples had little contact beforehand. But Ali said he and Shayna "started messaging, slowly established our relationship," then asked their parents if they could marry. "In our tradition, to be with someone is something sacred...Phone or no phone, we have to keep our customs alive," he said.

During my family's Gojal visit, we went to a wedding celebration. My two young sons were swept into a cricket match. My wife and I were asked to join a group selfie with the bride and her friends. There was no such thing as an uninvited guest.

"In these remote parts our relationship to our honored guests has never changed," Jan said. "Our kids go away to the cities, but deep down we are just mountain farmers." Gojal has planted a foot in the modern world, but it retains its traditions and ability to inspire. □



At a primary school in the village of Zood Khun, girls assemble to welcome a new teacher. Meanwhile, in the room next door, boys at an assembly discuss an excursion to the edge of the Chappursan River Valley, which runs parallel to Afghanistan's Wakhan Corridor – an area that once was part of the Silk Road. In Ismaili culture a strong emphasis is placed on education, particularly for girls.





An Ismaili bride awaits the arrival of her future husband. For years marriages in the Gojal region had been arranged by the bride's and groom's parents. Today many couples meet on social media sites and refer with pride to their bonds as "arranged love marriages." In an outlying settlement, a Wakhi couple brew tea inside their traditional mud home.





A mother and daughter, members of the Wakhi ethnic group, return from collecting fodder for their animals. The chore requires a two-hour round-trip on foot between their village, Hussaini, and their summer pastures. These chores may be done interchangeably by men or women.





At a school in Zood Khun, girls play a game of cricket during a break. Also in Zood Khun, family members of a soon-to-be-married bride pause to snap a selfie before the “love marriage” festivities begin.





The Grass-Eating Monkeys of Ethiopia

A protected savanna helps 'bleeding heart' geladas thrive—for now.

A shaggy male gelada pauses during his morning ascent from a cliff above East Africa's Great Rift Valley. Hundreds of the world's only grass-eating monkeys thrive on this plateau in the central Ethiopian Highlands, where villagers for centuries have protected the vegetation.

A gelada leaps over a small runoff stream as an infant (obscured except for its tail) clings to her back. Geladas live only in Ethiopia, but their now extinct relatives once inhabited lands from South Africa to southern Europe and as far east as India.





Male geladas' outsize canines aren't used for hunting. Instead they're used when fighting, threatening other males, or defending themselves against predators. Geladas' specialized molars are unlike those of other living primates and help the monkeys grind grass.





By Craig Welch
Photographs by Jeffrey Kerby
and Trevor Beck Frost

It's daybreak at 11,000 feet, and somewhere below, the monkeys are stirring.

Admassu Getaneh marches past flowering herbs and thick grass along the edge of a plateau in the central Ethiopian Highlands. Morning sun glints off his Kalashnikov rifle. At his feet basalt pillars plunge down to East Africa's Great Rift Valley. Soon an unearthly screeching will begin as hundreds of primates awaken from their nightly cliffside slumber and vault onto the plateau like an army of furry circus performers. But Getaneh isn't here to see that.

Short and slight in camouflage gear, Getaneh turns his back to the escarpment. He raises his binoculars. "I can see all the action this way," he explains. *Theropithecus gelada*, sometimes called the bleeding heart monkey, may not draw Getaneh's attention. But his presence helps explain why geladas here thrive.

On and off for nearly half a millennium, rural enforcers have done what he's doing today: patrolling the perimeter of a 42-square-mile high savanna called the Menz-Guassa Community Conservation Area, or simply, Guassa. Getaneh, a hired gun and former soldier, is here to make

sure that no one steals or ruins the grass.

If you want to protect the world's only grass-eating monkey, saving the grass is a good start. But Getaneh's forebears weren't in it for geladas. They were trying to save themselves. Native vegetation is everything in the highlands. Slender, sturdy stalks get strung into thatch and used for roofs. Men braid grass into rope. Women and children tie blades, sheaths, and stems into brooms and torches. Grass gets stuffed into mattresses. The prickly shafts even drive off fleas.

Yet across the misty highlands, where about 80 percent of Ethiopians live, grasslands, meadows, thickets, moors, and swamps are deteriorating into rock and dead earth. The population is exploding. (Home to an estimated 100 million people, Ethiopia, after Nigeria, is Africa's second most populated nation.) Farms sprawl across damp, rich land, displacing native plants that help the ground hold moisture. Erosion wipes out 1.5 billion tons of topsoil annually, pushing subsistence farmers to even more marginal ground. Farm animals trample soil, and with 49 million



Geladas eat well in the Menz-Guassa Community Conservation Area because the vegetation is diverse. Admassu Getaneh, a former soldier who manages the area, known as Guassa, patrols for farmers illegally grazing their livestock or for poachers harvesting grass.

cows and 47 million sheep and goats, Ethiopia has more livestock than any other African country. That upends a delicate balance between native flora and rodents, reducing food for everything from Abyssinian hares to wattled ibises.

This pattern plays out across Ethiopia—almost everywhere, it seems, except here. In Guassa the grass is high and wavy, the torch lilies and giant lobelia left to grow for years. It's not a park. Local villagers run this place. A complex communal system determines where livestock grazes, who cuts grass, and when. As a result this landscape one-sixth the size of Nairobi is among East Africa's healthiest. Nearly a quarter of the country's endemic mammal species live here. There are about two dozen of one of the world's most endangered canids, the ginger-furred Ethiopian wolf. Guassa is a hot spot for klipspringers, civets, African wolves, and hyenas. And unlike elsewhere in Ethiopia, its 800 or so chattering geladas live much as they have for thousands of years.

This small but spectacular wildlife success story is, in other words, a happy accident. I came

to Ethiopia to see whether Guassa could serve as a model for conservation. What I found was a region changing so quickly that I had to wonder, Can Guassa's monkeys and farmers navigate the pressures to come?

WEEKS BEFORE MEETING GETANEH, we fled the crowds and dust of the capital, Addis Ababa, and corkscrewed into the clouds toward Guassa. Scientist and photographer Jeffrey Kerby and I passed dry farms and rock huts. We saw women trailing donkeys stacked with hay. Men prodded goats with long staffs. Ethiopia may evoke images of camels and harsh salt pans, but it's mostly mountains. The first trickles of the Blue Nile start in the highlands. We were headed to Africa's roof, where Kerby is part of a decade-long gelada research project founded and run by Peter Fashing and Nga Nguyen, anthropologists at California State University, Fullerton.

We crested one last rise. The parched earth and trees gave way to a lush, vivid carpet of green. Almost immediately, our hosts appeared. Three

scampering geladas crossed the road, the smallest doing rhythmic half cartwheels. One landed on a rock 10 feet away. His eyes clocked us as we passed. A hay-colored mane spilled down his shoulders. His arms and fists appeared stuffed in black evening gloves. He looked almost regal.

Geladas, one of the flagship species of Africa's alpine grasslands, are found only in the Ethiopian Highlands. They are the smallest vestige of a genus that millions of years ago stretched from South Africa to Spain and into India. Once among the most prominent primates—one species was the size of a gorilla—they were likely driven to extinction by climate changes, competition with more adaptable baboons, and our ancestors, who butchered them. Today all that remains of *Theropithecus* are geladas, which offer valuable, if imperfect, insight into the world inhabited by our predecessors. There is no other animal like them.

Hours after arriving at the research camp—seven tents, a rarely used bucket shower, and a muddy tepee that serves as a guard shack—Kerby and I set off. We walked past a hidden camera trap. Sixty-five monkeys sat in a meadow. The air smelled of thyme. The monkeys didn't look up as we waded through. A baby sprawled on its back, one adult grooming its face, another stroking its leg. "That kid's getting the deluxe treatment," Kerby joked.

Geladas' most recognizable features are crimson patches of hairless skin on their chests. In females, this region changes color, and tiny sacs around its edge fill with fluid, often indicating that they are ready to mate. The pink on dominant males darkens to red. Other primates signal sexual readiness with their rumps, but these monkeys spend most of the day scooting on their rears, gorging. Most primates climb trees to eat fruit and leaves. Geladas use opposable thumbs to pluck grass blades and herbs. Like zebras, they mince food with their molars. In theory, Kerby said, "primates shouldn't eat grass." From a nutritional standpoint, grass holds little energy. Getting enough takes work and time. Such inefficiency would have made it hard to fuel the evolution of

a big brain. That might explain why geladas are less curious than, say, Botswana's chacma baboons when shown dolls or rubber balls. But that doesn't mean these monkeys aren't crafty.

Kerby and I squatted and listened. The air filled with squeaky chewing. One animal emitted a guttural seagull honk. I heard shrieks as if from squabbling crows. A female grunted "Uh, uh, uh," which Kerby said roughly translates to "Yo dude, I'm right here." Geladas form roving primate cities, arranging themselves in herds of several hundred. They communicate using one of the largest vocal repertoires of any nonhuman primate. Their lip-smacking "wobble" may even offer evidence that facial noises were a precursor to human speech. To document behavior and family dynamics, researchers give geladas memorable aliases. That can make life on the plateau seem at times like a daytime soap opera.

Tiny Astral, for example, is known for starting fights, swiping at larger monkeys, then ducking behind her mom, Autumn, like a spoiled mean girl. Lydia isn't the best mother to Lobelia, so Lydia's sister, Lox, often steps in. When Lydia abandons her offspring, which is often, Lox lets Lobelia hitch rides on her back. Five Dollar Foot-long (named for a sandwich) once stood on hind legs with arms outstretched as if desperate for a hug. Instead, his mother, Frodo, slapped him.

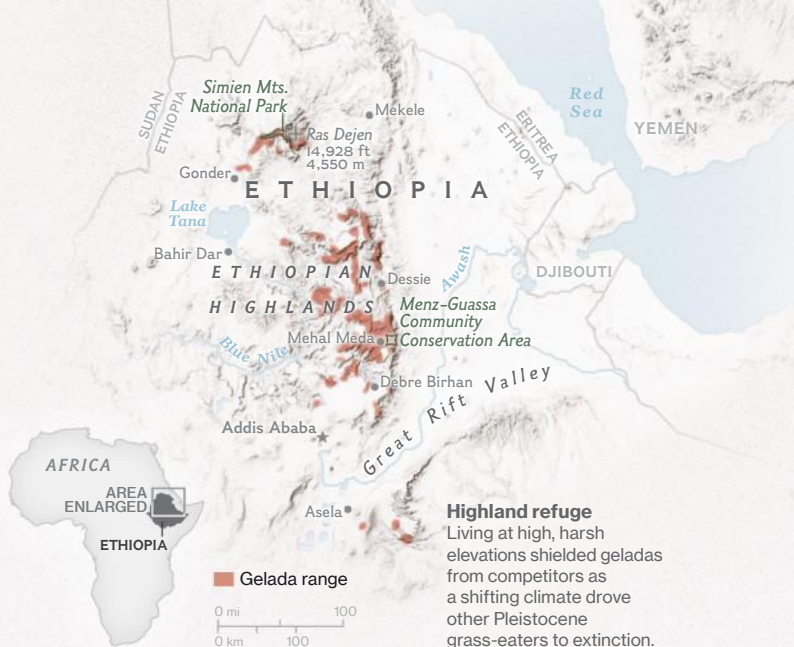
Females form a sisterhood, moving in reproductive units with one or a few males. Geladas aren't monogamous, so male-on-male encounters are often fraught. Take Reverend Lovejoy. When this leader, named for a preacher on the television show *The Simpsons*, spied a rival's infant in rich grass, he screamed. He flapped his eyelids and flipped up his lips. He bared impressive daggerlike canines. Geladas don't use these teeth for hunting. They're for display and fighting. Reverend Lovejoy raced to scare the youngster, but then his rival swooped in. They faced off, inches apart, huffing, until the rival backed down.

Guassa researchers, from Ethiopia and abroad, have followed the minutiae of the daily life of almost 500 individuals. They monitor activity, study relationships, track births, and document deaths. While studying responses to dying, they

■ **Society Grants** Your National Geographic Society membership helped fund this photography.

Survival of the Grass-Eaters

The geladas of the Ethiopian Highlands are often mistaken for baboons but are actually the last members of their own genus, *Theropithecus*. The unique morphology, diet, and behavior of the world's only grass-eating monkeys are helping scientists hunt for clues about primate evolution.



Highland refuge

Living at high, harsh elevations shielded geladas from competitors as a shifting climate drove other Pleistocene grass-eaters to extinction.

CLOSEST LIVING RELATIVES

Geladas (below, left) are similar to baboons, but with key evolutionary differences.

Average length (male)

2 feet



Gelada



Olive baboon

MALE GELADA

MALE OLIVE BABOON

Grass-grinding teeth

Geladas' canines are for fighting and display, with smaller incisors and larger, serrated molars for grinding grass. Baboons are omnivores.



Gripping hands

Geladas' longer, stronger thumbs and relatively shorter index fingers give them a pincerlike grip for pulling grass.



A male's thick cape provides warmth and may attract females.

Red chests

Geladas' red chest patches are unique among primates and are highly visible, even while they sit to forage – which is most of the time. Among male geladas, dominant individuals have the reddest coloring.

MANUEL CANALES AND LAUREN C. TIERNEY, NGM STAFF; SHIZUKA AOKI, TONY SCHICK
 SOURCES: RYAN J. BURKE, UNIVERSITY OF OXFORD; VIVEK VENKATARAMAN, HARVARD UNIVERSITY; JEFFREY KERBY, DARTMOUTH COLLEGE; PETER FASHING AND NGA NGUYEN, CSU FULLERTON; BIREN PATEL, UNIVERSITY OF SOUTHERN CALIFORNIA

watched an infant, Tussock, cry alone beside her dead mother, Tesla, as the herd disappeared into the distance. They've solved riddles. Though geladas bolt or freeze when most carnivores pass, these monkeys seem unfazed by wolves. Rather than scaring the herd by picking off baby geladas, wolves have learned that the monkeys flush out rodents, and the wolves actually get more to eat.

Yet much about geladas remains unknown. After a revolt in Ethiopia ousted Emperor Haile Selassie in 1974, a civil war made fieldwork difficult. In the early 1990s uprisings drove out the ruling communist junta, the Derg, and scientists returned. Today it's still not clear how many geladas are left. A few hundred thousand? Tens of thousands? Most of the country's terrain has been converted to agriculture. There are simply too many farms, too much erosion, to support a

small buttes. Hiking through underbrush. Looking for thieves. We have to keep moving. We have 12 miles to cover.

Getaneh runs Guassa's conservation office. He protects it from those who'd bring harm. No one lives in Guassa, but 45,000 villagers pack its outskirts. Residents plant barley, lentils, potatoes, and sometimes wheat. They raise cows and sheep and burn livestock dung to cook distinctive Ethiopian flatbread, called injera. Small farm groups, called *kebeles*, elect representatives to oversee the landscape. Managers close rangeland for months or years until *Festuca*—the grass for which Guassa is named—is flush and ready for cutting. That doesn't stop everyone. Thieves with hand scythes dart across hills, illegally swiping grass to sell as far away as Debre Birhan. Poachers dig out the roots of flowering plants for firewood.

If you want to protect the world's only grass-eating monkey, saving the grass is a good start.

rich array of grasses. Gelada numbers are high in the Simien Mountains, but that northern region is overrun by livestock. Many natural predators there are gone. Throughout the highlands, scientists have found small populations of monkeys surviving even when hemmed in by farms. But for how long?

Guassa is different. Carnivores abound. Geladas' diets are typically 90 percent grass, but here they eat more than 60 types of plants, so grass makes up just over half of what they eat, likely paralleling the diet of some early hominins. *Theropithecus* is helping scientists learn how human ancestor *Paranthropus boisei*, once erroneously known as Nutcracker Man, may have thrived on similar vegetation. "Studying gels here isn't like studying them in other places," Kerby said. "This place is a window into a bygone era. And there are only so many time machines left." Guassa just managed to get things right.

GETANEH FIXES ME with a patient, crooked smile. He, Kerby, and I are on patrol. Yo-yoing up

Getaneh sometimes tracks outlaws with teams of scouts. Often the scouts patrol without him. When Getaneh is alone, he relies on stealth. He is a furious ghost.

Guassa's land-use ethic is steeped in legend and in the church. In the late 1600s, according to oral histories, two Coptic Orthodox Christians, Asbo and Gera, stumbled onto Guassa. Both claimed its bounty. So the duo galloped their horses, dividing the land where the first steed fell. Communities split into parishes that answered to an elected leader who protected grass at all costs. Shared resources without strong management often fall victim to selfish acts by individuals. Peer pressure and association with the church seemed to help in Guassa. Preservation was an almost spiritual obligation. Villagers prided themselves on stewardship. Grazing seasons even ended on religious holidays. ("Usually when these types of common properties lean on sacred institutions, they become sacred themselves," pointed out Ethiopian scientist Zelealem Tefera Ashenafi, a Guassa expert.) And when



A billowing cape spills down past the shoulders of a mature male. Scientists suspect that this, like the red patch of hairless skin on his chest, may be a sexual signal, alerting females to his virility or displaying his strength to other males. Grooming (below) is useful not only for picking off parasites but also for keeping family alliances strong and stress levels low.



all else failed, there were men like Getaneh.

We sit while he recounts a story: Once, spying a grass thief, he crept up and tapped the poacher's backside with his weapon. The frightened man turned. Seeing Getaneh, his bladder failed. Getaneh laughs at the retelling. But his job also brings danger. Bandits—*shifta*—pass through, selling arms left behind from the civil war or from conflicts with Eritrea. Getaneh has been shot at and attacked with stones. One poacher with a knife tried to start a fight. Drunks in bars in nearby Mehal Meda have vowed to kill him.

These days theft usually means fines or jail. But memories here are long, and history is never far off. For centuries penalties were brutal, to serve as deterrents. Fines were to be paid in lion skins or cabbage seeds—neither found in Guassa. So authorities beat and excommunicated

up short, startled. A large spotted feline had rushed into the brush. This was not a serval, Kerby suspected, but a leopard. I think about that now, and about this place. Across Ethiopia a fraction of native highland vegetation remains. Yet Guassa is still ecologically rich. This ecosystem has survived revolutions, occupations, famine, and corruption. It has outlasted national governments. Under the right conditions, local conservation works. But ecosystems are fragile. The reign of the Derg, and subtle changes since, hint at how easily it can all come undone.

GUASSA FARMERS aren't charmed by the monkeys. Villagers tolerate them. Smart geladas climb atop fresh-cut piles of barley to feast. Villagers chase off hungry monkeys raiding nutrient-rich row crops. When grass is well managed, there's

This ecosystem has survived occupations, famine, and corruption—and outlasted national governments.

poachers. Illegally grazing cows were slaughtered, their skins stretched and given to the church for drums. Homes thatched with stolen grass were burned.

We start hiking again. After a mile or so, Getaneh points out a fresh earthen pit. Around it, dirt is charred. Someone has cut and burned heather to make charcoal. We see small grass cuts. Poachers have been through. Getaneh heads to high ground and scans the plateau. "They are not here," he says. I ask if he thinks he'll catch them. He shrugs, sitting down. From his breast pocket he pulls a skull he'd found on the trail, probably from a duiker. It is no bigger than his palm. Without someone watching, he says, grass theft would be rampant. Farmers with sick cows would slip into closed meadows. As the grassland shrinks, monkeys would steal more from farms. That could lead to more dead monkeys.

We round a corner. Perched on a rock near a patch of Saint-John's-wort, a brown francolin stares across the valley. Days earlier I'd walked near this spot with Kerby. He'd suddenly pulled

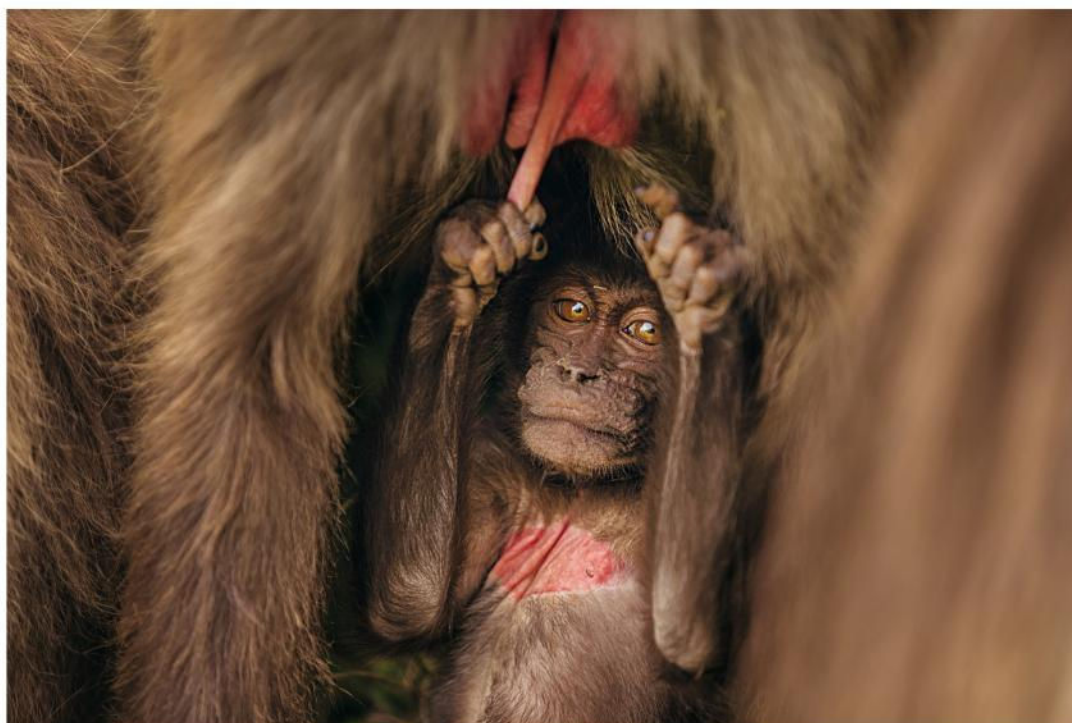
enough for people and monkeys. When the Derg was in power, some villagers say, grass was not managed well at all.

One morning Kerby and I picked our way through light rain down a steep, slick path to see Tasso Wudimagegn, a farmer and a scout for the Guassa Gelada Research Project. He had witnessed a transformation in Guassa. He had also undergone one himself.

Inside his mud-and-rock home, his wife boiled coffee over an open fire. We sat beneath walls papered with torn magazines displaying images from around the world—baseball games, smiling children, tranquil beaches. Growing up, he had despised geladas. He blamed the Derg, which had nationalized land and disbanded Guassa's oversight, for inciting the hatred. Grazing and cutting increased. Many farmers believe grasslands shrank, and with more human encroachment on the monkeys' natural feeding grounds, geladas raided farms more often. At the age of five or six, Wudimagegn tried scaring the monkeys off. Kids yelled and hit monkeys with stones. But geladas



Play fighting helps juvenile geladas develop and learn the limits of their own strength. Infants maintain frequent contact with their mothers. A young monkey may hitch rides on its mother's back, hide behind her and play peekaboo with other primates, or find refuge beneath her chest (below).





Geladas huddle for warmth. Getting enough calories from grass, herbs, and seeds takes a lot of work, so geladas spend most of their days scooting around on their buttocks. This frees up their hands to pluck more grass.



When it's time to give birth, Guassa's normally highly social geladas often isolate themselves to avoid aggressive behavior from other monkeys and remain silent in an effort to evade predators.





bared their teeth, and the children fled. When he grew older, he built traps. He beat geladas with an Ethiopian staff, called a *dula*.

These days Wudimagegn feels sheepish about such mistreatment. “I was wrong to think like that,” he said. Oversight in Guassa is better than ever, but the community is in flux. The property system has shifted. Once church based and limited to the descendants of its founders, Guassa’s stewardship is now more secular, more open to newcomers who don’t share its history. The underlying dynamic that makes local conservation work is the perception that everyone’s in it together. But now resentments are budding. A sense of belonging is eroding.

Wudimagegn admitted that he sometimes stares at his walls with longing. The magazines depict “better places,” he said. He wants to move

gone, but other parts of the country are again wrestling with political instability. Climate change is making higher land even more suitable for farming. By 2050 Ethiopia’s population could increase 10-fold from what it was in 1950, to 188 million. A country less than twice the size of Texas would have nearly seven times as many citizens. Incomes are rising, but one-third of Ethiopians still live in extreme poverty. So the government is encouraging Chinese investment.

Making our way back toward Guassa, I see a meadow popular with geladas. Yellow tractors and earthmovers are paving a dirt road that skirts the meadow’s edge. Machinery is ripping up wetlands thick with nutritious vegetation. Power lines and cell towers and a rudimentary tourist lodge have all been built within the past decade. And why not? Life here is hard, opportunity is

With the arrival of tractors and power lines, can these monkeys adapt to the hardships to come?

to the city, make more money, give his children a better education. It’s a universal story—people want the life they see others have.

AFTER AN EXHAUSTING NINE-HOUR walk, Getaneh, Kerby, and I reach Guassa’s end. We hitchhike toward Mehal Meda. Along the way a different landscape spills before us: acre after acre of rolling farms and crumbling earth, each plowed plot hugging the next in an unbroken sea of agriculture. That, Kerby says, is how most of the rest of the highlands look.

Guassa avoided that fate in part because locals kept control, rules were clear, oversight was strict, and users were invested. Nobel Prize winner Elinor Ostrom found that similar strategies also succeeded in places as disparate as Swiss farming villages, Japanese forests, and New England lobster fisheries. Comparable efforts are being employed in Namibia to protect wildlife. But Guassa for centuries was aided by elevation and remoteness, which kept newcomers at bay. Now new pressures are all around. The Derg is

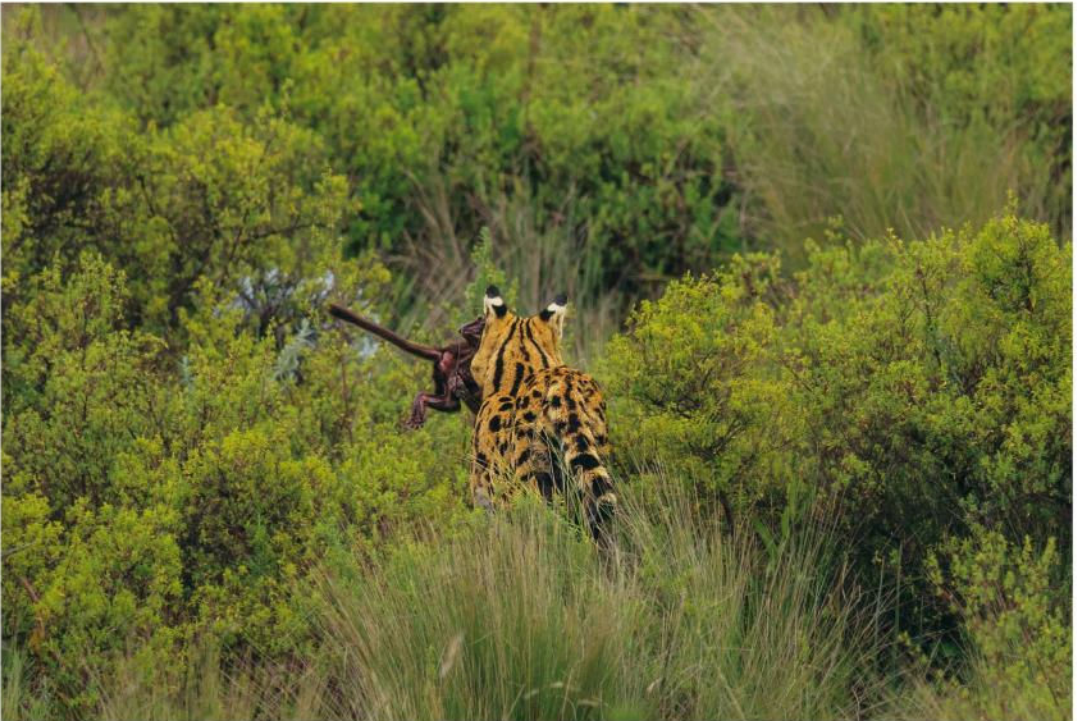
scarce. Development, ecotourism, and access to more markets could pull people out of poverty and help modernize the economy. But all this will put the region and its monkeys to the test.

Back in camp on one of my last evenings, Kerby and I follow the monkeys as they move in tight formation beneath a setting sun. One by one, amid their squeaks and grunts, the geladas clamber back over steep cliffs, where they will huddle until dawn on thin, rocky ledges. Honed over millennia, this practice protects sleeping geladas from hungry hyenas or other night-prowling predators. As I watch the stragglers break into a languid trot, it’s hard to escape a sense of unease. Evolution has prepared our fellow primates for many threats. But there will be no place to hide from what we’re about to throw their way. □

Photographer and National Geographic Grantee **Trevor Beck Frost** finds joy in places “where nature is wild and as it should be.” Photographer **Jeffrey Kerby**, also a National Geographic grantee, is a scientist at Dartmouth. This is their first feature for the magazine.



Some young geladas fall prey to disease or infanticide by aggressive bachelors. Mothers may carry dead infants for weeks. A serval (below) snatches a live newborn so young its umbilical cord and part of the placenta remain attached. The cat disappears into a thicket of Saint-John's-wort as the herd of geladas stampedes onto the flats.



As darkness falls on Guassa, geladas break into a run down a slope toward their sleeping cliffs. They will spend the night perched on narrow rocky ledges, trying to stay safe from leopards, hyenas, and feral dogs.







Two adult males look out over a landscape in transition. Agriculture is overtaking Ethiopia's grasslands, and climate change is making higher ground more suitable for farming. With so many pressures, can protected areas like Guassa survive?



In summer 2016 Iraqi forces and an international coalition moved in on the ISIS-held city of Qayyarah, south of Mosul, part of a war to drive the jihadist group from Iraq. ISIS set fire to oil wells around the city, then fled. Residents were left in an environmental wasteland.



LIFE

As allies moved to retake Mosul, fleeing Iraqis told harrowing stories of the Islamic State's brutality—and made it clear that the damage to their country will endure.

AFTER ISIS







Aware that its neglect of Mosul's citizens contributed to the rise of ISIS, the Iraqi government now helps those who remained in the city during the fighting. For mothers in Gogjali, one of the first neighborhoods to be liberated, food distributions are an essential lifeline.

السلطان



لنا بهذا العمل عرفانا للدماء التي سبغت طريق النصر... لن

الشهيد
محمد
الجبوري

الشهيد
رشوان
سليمان
الجبوري

الشهيد
رفاه
سليمان
الجبوري

الشهيد
رفاه
سليمان
الجبوري



ساحة فدس



في يوم ٢٠١٤/١٣/١٥ قُلت عمليات داعش الارهابية باعدام كوكتبة من رجال العلم الابطال (فدس) ... وقد قم



الشهيد
ناعي
محمود
شنج
بوري

الشهيد
هاكم
خلف
العباس
المزراوي

الشهيد
فاروق
حسن
العباس
المزراوي

الشهيد
صادق
حسن
العباس
المزراوي

الشهيد
الشاخي
طلب
الحسين
الجبوري

In Al Alam, a town near Tikrit, 11 local men were publicly executed near the intersection where a memorial to them now stands. Monuments, billboards, posters, and artwork commemorating the victims of ISIS's atrocities are increasingly common around Iraq.

By James Verini

Photographs by Moises Saman

The Kurdish soldiers stood on a berm, next to a gunner's dugout, in a corner of their position. It was one of several forward positions on a front line that ran along the crest of a mountainside and faced west onto the Tigris River Valley. The sun had set on a late summer day—the driest season in Iraq, when land and sky seem to merge. Still, through the thickening dark the soldiers could make out, on the river's near bank, the lights of the city of Mosul. This was a vista they could have described in their sleep—for months these soldiers, who were with the *peshmerga*, the army of Iraqi Kurdistan, had surveilled and mapped and discussed every inch—but its fascination and menace never dimmed. Everything they looked at belonged to the Islamic State.

It was late July 2016, and the battle for Mosul, long rumored, was soon to begin. A liberation force was assembling. Iraqi soldiers had beaten the Islamic State, also known as ISIS, out of Fallujah and were now fighting their way north toward Mosul. The *peshmerga* was pushing in from this mountain. U.S. and European forces were massing, as were soldiers and militiamen from Turkey, Iran, and elsewhere. It was the biggest international show of force against ISIS yet. ISIS had held Mosul, Iraq's second largest city, for two years.

Mosul's fall would drive the jihadists from the country once and for all, the planners hoped.

Inside Mosul there was panic. The United Nations had estimated that more than a million people would be displaced by the battle. (Before ISIS, Mosul had about 1.4 million residents.)

Civilian casualties would be terrible. Residents were escaping the city by any means they could, and this Kurdish position was the terminus of a popular escape route. Almost every night, people scrambled up the mountainside and arrived here with only the clothing on their backs.

Tonight the soldiers were expecting a family of seven. The father, a nurse, had phoned a cousin who lived near the mountain. The cousin had notified the commander.

The cousin, whose name was Tayeb, had been

As the battle for Mosul loomed, residents fled the city in any direction they could. One escape route led over the mountains into Kurdistan. Ayham Ali's wife, Nawal, and children followed him up the slopes at night, arriving exhausted but grateful to be safe.



When Ali bandaged the hand of a woman who wasn't covered, he was jailed and whipped.

able to give the nurse only the vaguest of directions: "Go up the mountain." Now Tayeb and the commander stood on the berm together.

Tayeb's phone rang. It was the nurse, Ayham Ali. Tayeb handed the phone to a Kurdish interpreter who translated the directions from the soldiers to Ali. (Ali spoke Arabic, the soldiers Kurdish.) In the pressure of the moment and his eagerness to encourage Ali, the interpreter gave the nurse a promotion.

"Where are you, doctor?"

An anxious voice came from the other end.

"Go 500 meters to the right. You'll see a small valley. Go into the valley."

The crying of a child came through.

"Don't worry, doctor. You're safe now."

A soldier switched on a flashlight and moved it from side to side.

"Tell him to follow the light," the soldier said.

"Doctor, do you see the light?" the interpreter said.

"Don't move the light so much. ISIS might see," said the commander.

For the next few hours, Ali hiked and then called for more directions, hiked then called. The connection broke off. For some time, nothing. When Ali called back, near 11 p.m., he was lost and worried. He had sent his eldest daughter ahead to try to find the way and hadn't seen her since. He thought ISIS had spotted them. The interpreter told Ali to describe what he saw around him.

"I know where you are. Don't go to the left. Go right. If you go left, you won't make it. It's too steep."

Announcing he was going down to look for them, Tayeb jumped from the berm.

Distended minutes passed. Near midnight

Tayeb returned carrying a small girl, her eyes wide and wet with fear. He put her down, turned around, and disappeared again. A soldier picked her up; he bounced her gently and cooed. Soon a boy and two more girls, one the eldest daughter, arrived, and Tayeb came back with the youngest child in his arms. He had dropped her, and her forehead was swelling, but she was silent.

The mother, Nawal, which means "gift," appeared. She wore a black abaya and black hijab. She sank to her knees. In a reverie or delirium she chronicled their ordeal to no one in particular.

"We were so hungry in Mosul. There was no money, no food," she said. "It's all right if we die here hungry. We're safe. This is the best moment of my life."

Ali, the last of the party, emerged behind her, looking ill with relief. His clothing was ragged, his scraggly beard glistening with sweat.

"Let's move. There are snipers," the commander said.

The soldiers brought the family toward the camp.

"We're here. It's fine if I die now," Nawal said.

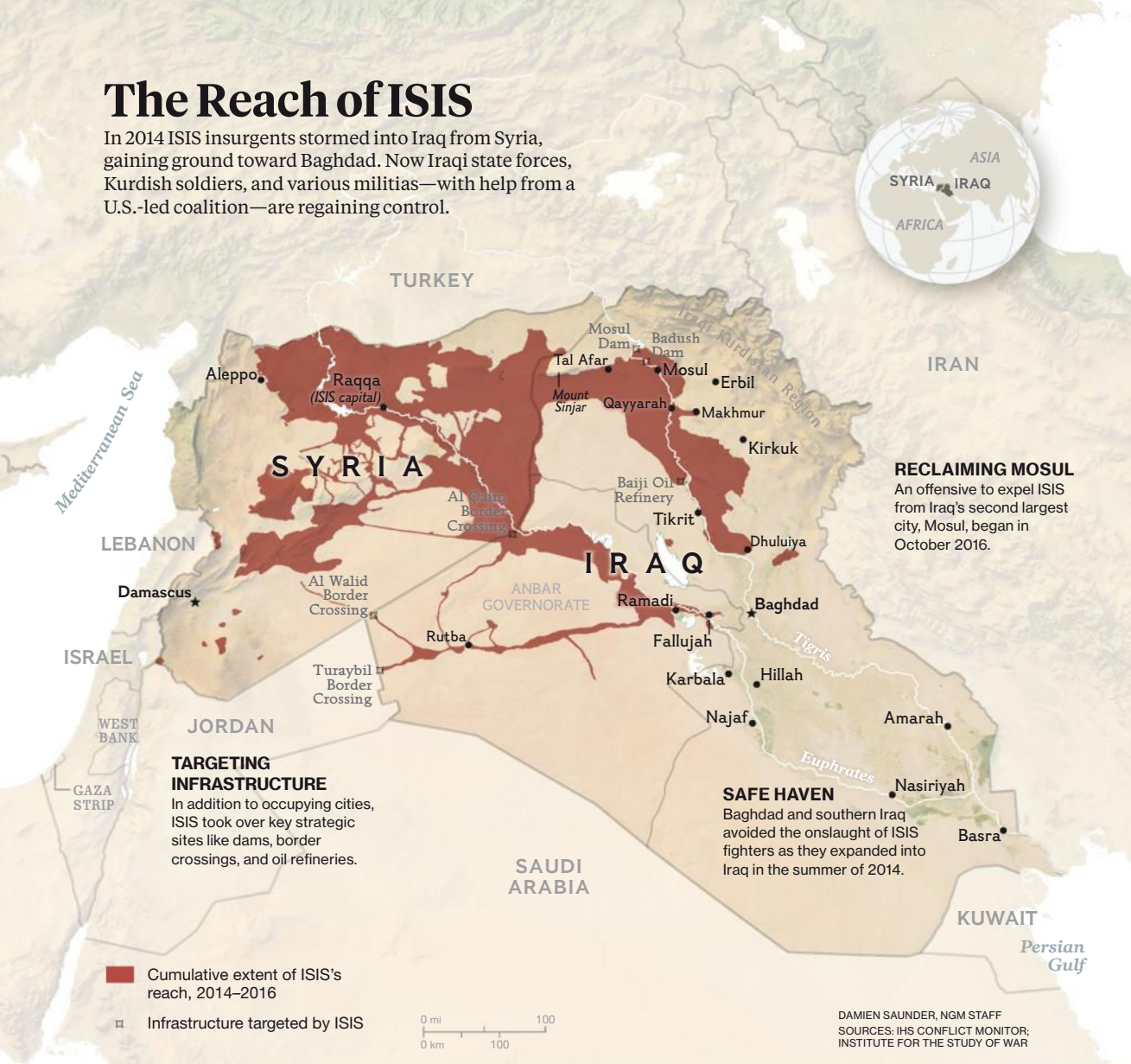
"I feel like I'm in paradise," said Ali, who took up his own narration. "It's not easy to leave your parents. But I was dying there. There were 20 of us. My brother sold ice cream. He made no money. We fought, he and I."

ISIS had seized Mosul two years earlier, in June 2014. The militants burned down the police stations and army checkpoints. They hoisted flags with the black-and-white ISIS logo, installed new imams in the mosques, new teachers in the schools. From the Great Mosque of al Nuri, the Islamic State's leader, Abu Bakr al Baghdadi, newly split from al Qaeda, proclaimed the creation of the Islamic State and himself its caliph. He commanded Muslims everywhere: "Obey me."

Some residents fled; others went into hiding. Many rejoiced. How Ali had felt, he didn't say, but at first, he recalled, life wasn't bad. He was able to continue working at the hospital. Soon enough, however, the misery began, the torture and the executions in public. With enough caution one could avoid them. Unavoidable was the tedious

The Reach of ISIS

In 2014 ISIS insurgents stormed into Iraq from Syria, gaining ground toward Baghdad. Now Iraqi state forces, Kurdish soldiers, and various militias—with help from a U.S.-led coalition—are regaining control.



ignominy of daily life. He was made to cut the length of his pants to adhere to the “Afghan” style ISIS leaders preferred. He was told to grow a beard, then grow it longer. To go in public, his wife had to be accompanied by a man in her family and cover herself entirely in black.

“If she wore even a sandal with a heel, she might be beaten,” Ali said. “They didn’t treat us like humans.”

The markets went empty. The electricity went off, then the water. ISIS got more brutal. When Ali bandaged the hand of a woman who wasn’t fully covered, he was accused of being sexually involved with her. He was jailed and whipped, and he counted himself lucky to still have his

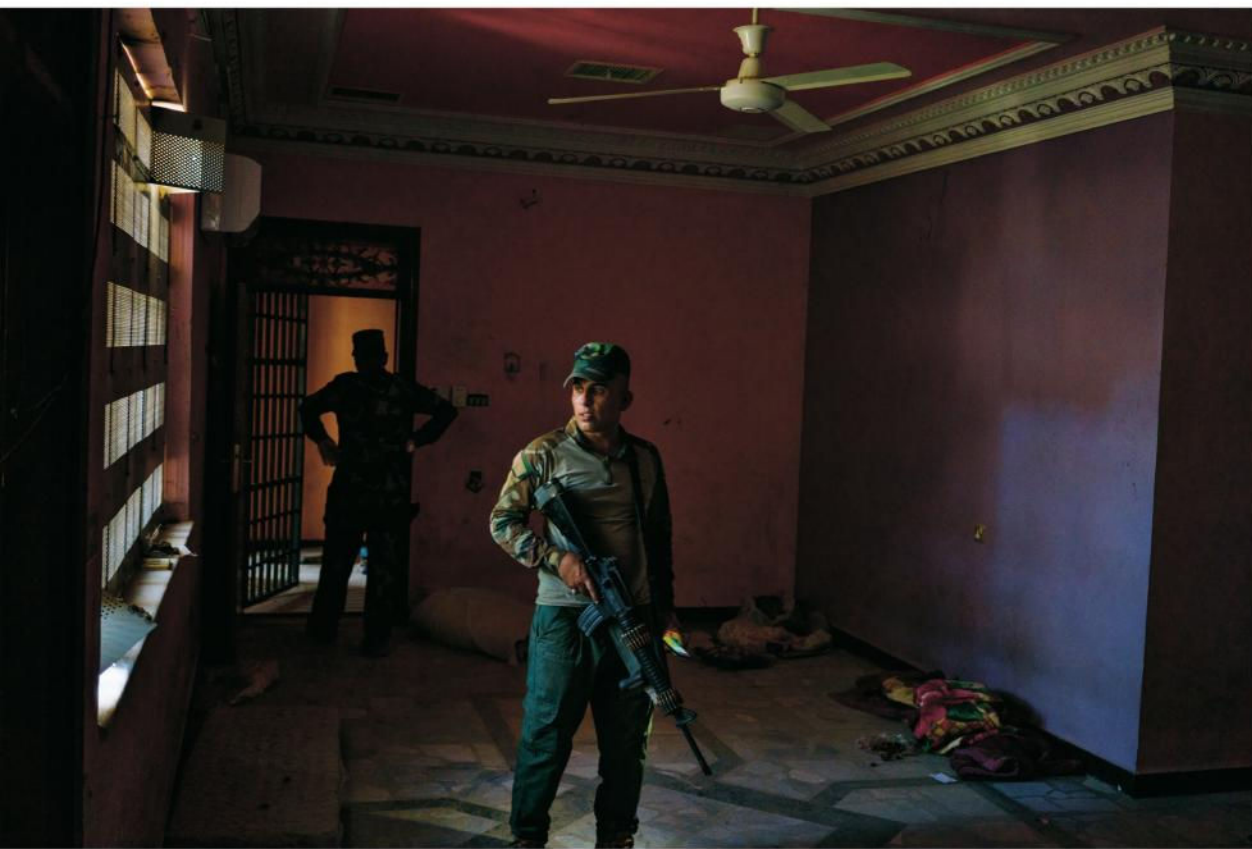
head. He realized he must risk a quick death and leave—or stay and die slowly.

THE ISLAMIC STATE began gestating, as a collective of Sunni Islamist groups, by 2006. Over the next half decade it gained shape and power, taking in former Baathist fighters left over from the time of Iraqi president Saddam Hussein, deposed in April 2003. In 2012 and 2013 it metastasized throughout Syria. In the first days of January 2014, it took up arms in Ramadi, the capital of Iraq’s Anbar Governorate. A few hundred militants seized much of the city. As they would in Mosul, the government forces collapsed, though they managed to hold on to part of Ramadi. For

In the war against ISIS, Ramadi has sustained more damage than any other Iraqi city. Yet even there, displaced people have created homes. On the city's fringe, families took over apartments in a half-destroyed complex. It lacked power or water, but there was safety.







most of the next two years, Ramadi's residents lived in an intermittent war of attrition. The situation drew comparisons to partitioned Berlin.

The Iraqi military reassembled and was joined by Shiite militias and a U.S.-led coalition. At the end of 2015 Ramadi was "liberated," as state television put it. Whole districts were not just uninhabitable but unrecognizable. It was impossible to imagine people moving back. Yet they were.

A taxi drove into a deserted, ruined road and parked. It was unclear why. There was no one hailing a taxi—there was no one anywhere. Then the driver, an old man in a faded gray dishdasha, got out and disappeared into the wreckage. Within it was his home. The second level had been sheared off in an air strike, as though by a giant scythe, but the first was standing, tentatively. Where his front gate had been, he had hung a blue plastic tarp. He had returned four days earlier, he said, expecting to find nothing. He would settle for half a house over no house at all. The problem was, it couldn't be reached. So he'd rented a bulldozer and cleared a path through the hill of splintered furniture and cinder block, from the pinnacle of

which protruded the front wheel of a motorcycle.

"We think there are bodies in there," he said. "We can smell them." He knelt, put his nose to a small hole in the wall that was keeping the pile at bay, and inhaled. He bade his visitors do the same. "Smell that?"

The home of a furniture dealer, Abdula Zuhair, had been in the government-controlled section of the city, but only barely: The line of division had been a few hundred yards down the street. When ISIS came in, its men tied a laundry rope between homes on either side of the street—Zuhair recounted this by tracing a line in the air with his glowing cigarette—and then draped blankets over it.

At first there was a fragile stalemate between the government and ISIS. Zuhair had clients on the insurgent side and was permitted to go back and forth. Some differences were overt. For example, homes and businesses were spray-painted with the words "Property of the Islamic State Endowment." Shops had to close before each call to prayer, five times a day. The black-and-white ISIS logo was everywhere. Other differences



were subtler. ISIS considered depictions of the human form sacrilegious, and Zuhair noticed that on shop awnings and billboards the models had been cut away or painted over.

In 2015 Zuhair's teenage son went missing. Zuhair suspected ISIS was involved—the group was known to kidnap for ransom. So he crossed the blanket line and went to a patrol station. He explained that his son, who was 16, was developmentally disabled. The men were helpful, ordering that announcements about the boy be made at mosques. Soon after, however, a militant came to Zuhair's furniture shop. ISIS had his son, and Zuhair had three options: pay \$50,000 for his release, allow his son to join ISIS, or see him beheaded. Zuhair didn't have anything like that kind of money. He offered his truck and all the money he had.

Before he heard back, the Iraqi forces began their final assault. Zuhair and his family fled west to a government-held city where displaced people were gathering. There the boy's captors, apparently taking pity on him, secretly brought him to see his father. The boy was in the Afghan-style dress, and wisps of hair grew from his chin.

After ISIS retreated from Fallujah, the group's inventive cruelties were revealed. The mansion of a wealthy contractor (opposite) had been made into a prison, and a teachers college (above) into a court and execution chamber. Corpses were buried in mass graves under paving stones and floorboards.

"You must try to escape," Zuhair whispered as they hugged.

"I can't," his son said. "They're watching me everywhere. Maybe they will kill you or my mother."

He hadn't seen his son since.

One afternoon last summer, after Ramadi had been liberated, Zuhair drove into the city center, to his furniture shop. He climbed over the collapsed metal awning and through a window frame. The display area had been plundered. He climbed through a hole in the wall into the adjoining commercial space, which ISIS had used as a bombmaking factory. On the unfinished concrete floor were sacks of coarse gray powder, empty cigarette packs, and two neat piles of human excrement. Another hole led into Zuhair's twilight rear showroom, its overstuffed living

Mount Sinjar is home to the Yazidi people, held in particular contempt and brutally victimized by ISIS because of their blended religion. The mountain provides a stark backdrop for a memorial to Kurdish fighters who died battling ISIS.







room sets and fussy armoires coated in dust.

“My father opened this store in the 1960s,” he said. “It was the best furniture store in Ramadi.”

THE DAMAGE IN RAMADI was the most extensive of any Iraqi city, but it was not rare. ISIS and the war against it had left large portions of northern and western Iraq in ruins. The violence had stretched from south of Baghdad to the borders with Turkey, Syria, and Saudi Arabia, engulfing dozens of cities—in addition to Ramadi, Falujah had been overrun, as had Tikrit and Tal Afar—and hundreds of towns and villages. ISIS had decimated the Mesopotamian archaeological treasures of Nineveh and ancient Christian villages. It had attempted to wipe out the Yazidi people, whom it considered pagans. The fires it set at oil wells burned for months, causing untold environmental damage. By early 2017 the United Nations, its partners, and other organizations had erected 86 displaced-persons and refugee camps around Iraq. More than three million Iraqis had fled their homes.

With its promise of a pure and proud state,

ISIS appealed to many Iraqis—men and women, young and old, rich and poor. Only some were zealots, but all were fed up with one or another entrenched power. ISIS appealed to Sunnis sick of the neglect and abuses they had experienced under Nouri al-Maliki’s Shiite-led government. And it drew in Sunnis who looked to the selfish Gulf monarchies, the brutal, secularist military of Egypt, the westernizing Turks, and saw a void of valid leadership. ISIS also appealed to the marginalized and dispossessed. It is not a coincidence that Anbar is home to Iraq’s poorest and least educated citizens and that ISIS’s propaganda emphasizes the socialist undercurrent in political Islam. This class dimension of the war is often apparent, as are the other social rifts ISIS has heightened. As ISIS was being chased from Iraq, the alliance of Iraqis doing the chasing—Arab and Kurd, Sunni and Shiite, army and militia—was a delicate one. If not for a common cause, its partners would be at each other’s throats.

During the summer of 2016, Iraqi forces pushed north along the Tigris River. By August they had



reached a small riverside city, Qayyarah, the last strategic gain needed before moving on to Mosul. One day, in the midst of the battle for Qayyarah, an army convoy drove from the base in Makhmur to the front line. A beige pickup was followed by a Humvee and a cargo truck carrying 200 blue plastic garbage bags containing rice, tea, sugar, cooking oil for those displaced by the fighting.

In the front seat of the pickup was a prominent general from Baghdad, one of the many planners of the campaign toward Mosul—or at least one of the many generals who believed he ought to be planning the campaign. The pickup reached a burned-out village, and the road divided into parallel sand paths. The already nervous driver was at a loss. There could be IEDs anywhere.

“Follow the tire tracks—don’t go left or right,” the general, a squat, balding man, said, and kept talking at a group of adjutants jammed one upon another in the backseat. “In Baghdad we wouldn’t stand for these ideas,” he said, referring to ISIS’s popularity in rural Iraq. “But out here people are disconnected from the world. They can’t think for themselves.” Then he began singing a

Various Iraqi militias have joined the war against ISIS. In Hajj Ali, a town south of Qayyarah, a Sunni militia (opposite) formed by a local sheikh patrolled the roads. In Kirkuk a prisoner (above) who admitted working as a bombmaker for al Qaeda and then ISIS was held at a police base.

song from a YouTube video he’d been watching.

The driver drifted to the left.

“No, not that way. That road has bombs. Go straight. They’ll shoot rockets at us.”

“All of ISIS are sons of bitches, I swear,” the general went on.

“None of them are human,” an officer in the back agreed. He had his own theory as to the group’s motivations. “They’re all gay.”

“That’s true,” another said, agreeing with the slur. “I knew a man who joined ISIS. He was already gay.”

The driver drifted again.

“Where are you going?” the general said. “Do you see any tire tracks? Don’t think like a Kurd. What’s wrong with your brain?”

The convoy drove into the village, Jahala,



Iraq has insufficient resources to help the more than three million people displaced by its war on ISIS. Camps are short of food and supplies. This day laborer walking along a dusty road was lucky enough to find work near the camp where he lives.



Jahala 'has become like a refugee camp,' a tribal elder said. 'They come here with nothing.'

where the food was to be handed out. Hundreds of people had gathered in the central square. The men crouched in a line down the main road, shading their faces from the sun with ration cards, while the women stood in a less orderly queue in the shade. Every moment the lines grew longer. Soldiers stood with rifles ready. There was an explosion in a village across the river—a missile strike, or very large mortar—sending a plume of dirt into the sky. No one flinched.

The cargo truck backed up to the square, and the driver opened the tailgate. A tribal elder approached.

"This village has become like a refugee camp," he told the general. "The population has gone from 700 to 25,000. They come here with nothing. We need more help."

The general was handed a stack of ration cards. He read off names and handed out bags.

The air grew hotter, the lines longer, the women fretful.

"Give me a place here," said a woman, trying to wedge herself into the line.

"No, this is our spot."

"Where is the general? I want to talk to him."

People left their lines to approach the general and appeal to him personally, accompanied by murmurs of indignation. A man came up to him, but before he could open his mouth, the general said, "Don't talk. Get back in line."

It became clear there wouldn't be enough food for everyone, not nearly. The last bag was handed out. The driver closed the tailgate and started the truck's engine. Murmurs swelled into shouts, the lines into throngs. The general was surrounded. A soldier pointed his rifle to the sky and fired. A few villagers ducked; most took no notice.

As the general tried to open the door of the pickup, a group of old women begged him for food, their hands outstretched.

"There will be more food tomorrow, God willing," he said. "For today we're done, but tomorrow we'll have a thousand bags of food! Here, I'll sing it for you." He went into song. *"Today we're done, but tomorrow we'll have a thousand."*

THE ISLAMIC STATE broke off from al Qaeda because its leader, Abu Bakr al Baghdadi, was too bloody-minded even for al Qaeda's tastes. One conviction he and his jihadist alma mater do share is that, as historian of jihad David Cook has put it, "the entire world is united in a concerted effort to destroy Islam." But where Osama bin Laden built his organization on the belief that Islam's greatest foe was the "far enemy," the imperial West, until recently Baghdadi focused on the "near enemy," the impious governments of the Muslim world.

Worse still, Baghdadi sermonizes, are Shiites, a colonizing cancer within Islam. In this he follows on decades of sectarian politics in Iraq. In the 1970s the Baath Party deported people believed to be of Iranian birth. When Saddam Hussein went to war with Iran in 1980, he called himself the defender of the true Islam, the man who would protect Sunni Arabs from the Shiite Persian hordes, a menace since the seventh century. (This despite the fact that many Iraqi Shiites fought loyally for him.) Baghdadi is a child of this animus, which returned with the sectarian war of the mid-2000s, as much as he is of the U.S. occupation, and it has left him with a view of Shiites that can only be described as genocidal.

What then accounts for the irony that in Iraq his followers have almost certainly killed—and have certainly immiserated—more Sunnis than Shiites? Maybe this: ISIS marked a progression from al Qaeda not only in the professionalization of jihad but also in its theorization, to a narrowed vision in which the Muslim who most deserves the name is a killing Muslim—a Muslim killing not just infidels, not just apostates, not just Shiites, but killing any Muslim who isn't also killing. This vision was delineated most chillingly

by the late Palestinian theorist of jihad Abdullah Azzam. “Honor and respect cannot be established except on a foundation of cripples and corpses,” he wrote. “Every Muslim on Earth bears the responsibility of abandoning jihad and the sin of abandoning the gun.”

The only thing more apparent in Azzam’s words than hatred is self-hatred. This is a politics of profoundest shame. More than homicidal, it is suicidal. So, perhaps unsurprisingly, many of the corpses of ISIS fighters that turned up in the latter months of 2016 were the victims not of combat but of their own comrades.

As ISIS retreated toward Syria, evidence of the group’s sadism was on display nowhere so plainly as in Fallujah, the nerve center of Anbari rebellion. In January 2014 ISIS seized Fallujah. In late June 2016, after a month of fighting, Iraqi special-forces soldiers won it back. Days later a group of soldiers and police walked through the wreckage-strewn streets to the Fallujah Women’s Teachers Institute. This had been an ISIS court and execution chamber. The air was heavy with the scent of decaying flesh. In the entry corridor was a cluster of overturned cabinets. Files of the young women who had studied here, their photographs stapled to blue folders, fanned across the floor.

As the men came to a small courtyard, they put their hands to their noses in unison. A policeman pushed aside a chalkboard in the dirt, revealing a fibula. The bone jutted from a hole beneath a paving stone. They stepped closer. The hole was full of corpses in such a state of decay—no longer bodies, not quite skeletons—it was impossible to tell how many were there. In an adjoining hallway was another mass grave beneath the floor, covered over with a carpet and sofa. A police commander said these were believed to be ISIS members, executed on suspicion of cowardice or betrayal or some other infraction.

When ISIS had taken the city, its fighters had made for the impressive central hospital and turned it into a headquarters. A group of men inspected the hospital. They walked through a courtyard. Morgue trays were on the ground near a small, newly covered grave. A soldier put his

hand down to his waist to indicate the height of the body buried in it. During the fighting it had been too dangerous for locals to take their dead children from the hospital to the cemetery, so they buried them on the hospital grounds, in any space they could find.

In the emergency ward, framing and ceiling tiles hung down like jungle understory. A policeman—he went by Abu Nebah—searched for keepsakes, placing them in a plastic shopping bag. Taped to the walls were grainy photocopies of the ISIS logo and official memoranda on ISIS letterhead. Phrases hinted at desperate last days in power. “To all brothers and section chiefs, may God bless them,” read a memo. “All brothers should bring back their families immediately to the Fallujah sector within 20 days from the date of this notice. Whoever violates it will not be allowed any time off.”

As Abu Nebah looked through his booty—some Kalashnikov shell casings and a black nylon utility belt—he said he’d known the hospital well even before taking up this post. All four of his children had been born here. He’d fled in 2004 during the two battles of Fallujah. Later he became a policeman at the height of the insurgency.

“But none of that was as bad as ISIS,” he said.

When the jihadists came in, police officers who had the money to flee, did. Those who couldn’t, hid. And those who couldn’t hide gave themselves up. They were forced by the Hisbah, ISIS’s religious police, to stand up in mosques and public squares, in front of crowds, and declare their regret for having enforced the laws of the infidel government. Some were killed even after these rituals of public humiliation. Abu Nebah’s family fled with a hundred others, basically his entire neighborhood.

He was asked why he came back.

“This is our home,” Abu Nebah said. “Anyway, it’s not as bad as Ramadi.”

AFTER THE NURSE AYHAM ALI and his family made it from Mosul to the soldiers’ post on the mountain, they were driven down to a small compound. Out of the grip of ISIS for the first time in two years, they slept through the night.

Although the Iraqi government implored residents to stay put during the battle for Mosul, more than 100,000 fled. After gathering at the city's edge, they were trucked to camps, 86 of which had been set up around Iraq by early 2017. Countless other Mosul residents resettled with family or friends.





ISIS often installed itself in essential institutional buildings: hospitals, government offices, military bases, and schools, like this gutted structure in Hammam al Alil, a city south of Mosul. It will be years before the damage caused by ISIS – psychological as well as physical – can be repaired.







The next day Ali was brought into an office and told to sit down. He was unrecognizable. Clean-shaven, he wore new pants and a collared shirt. At a desk in front of him sat a general, while on couches on either side sat officials with the Asayish, the Kurdish intelligence and security agency.

“We just have to ask you some questions,” the general said.

One of the officials, a stout bald man, led the interrogation. The Asayish had informants in Mosul. He showed Ali an iPad with a Google Earth image of his street in Mosul and asked Ali to point to his house.

“There’s an ISIS house just nearby,” the interrogator remarked.

Ali was nervous. He knew the fact that he’d waited two years to flee Mosul didn’t count in his favor. Nor did it help that he and his family had moved to Mosul from an outlying village shortly after ISIS took control of the city. He saw there was no point in trying to hide this.

“We left our village because we were worried it would be destroyed in the fighting,” he said.

The interrogator was unfazed. He was more

interested in why Ali had waited so long to leave the city.

“When ISIS came to Mosul, the routes to Kurdistan were still open, weren’t they?”

“We thought we couldn’t get to Kurdistan,” Ali said. The roads were said to be mined. People who tried to flee were killed.

“Do you know of people from the village next to yours who joined ISIS?” the interrogator asked.

“I know of two men. I know their father’s name. I don’t know their names.”

“And what about from your village?”

“I know all of them.”

“List them.”

Ali paused for a moment.

“My cousin was ISIS,” he said.

Again the interrogator was unsurprised.

“Yes, we know about him.”

Ali explained that he had treated his cousin’s shrapnel wounds. He hadn’t wanted to, but his cousin had insisted. He was ISIS—Ali wasn’t going to refuse.

Ali was asked for phone numbers. He said he didn’t have any.



“I only know these men. It doesn’t mean I worked with them.”

“I know,” the interrogator said. “What about Facebook?”

“I don’t have Facebook. I don’t even have a phone to use Facebook on.”

The interrogator asked about the warden of the ISIS jail Ali was put in, about checkpoints, tunnels, artillery positions. The atmosphere in the room when the questioning was done was not one of relief. It was clear the interrogators didn’t entirely buy Ali’s story. The Asayish knew that many fleeing from Mosul lied about their involvement with ISIS. The problem was finding proof. One of the interrogators said privately, “Arabs all lie. All of them have had some connection with ISIS.”

As the interrogation ended, Ali said, “I don’t want to go to a refugee camp. My wife is so young. There may be young men there. They’ll see her.”

“We all have wives,” the general said. “I haven’t seen my wife in six months.”

Ali and his family were driven to a camp. It was newly built, in anticipation of the battle for Mosul. The white tarps of the tents were still

A sandstorm tinges the view (opposite) in the northern Iraqi homeland of the Yazidis, enslaved en masse and driven out by ISIS. In Bashiqa, a small city east of Mosul that ISIS controlled until November 2016, families gone for two years have tentatively made their way back. Some of their homes are intact or reparable (above); others were obliterated.

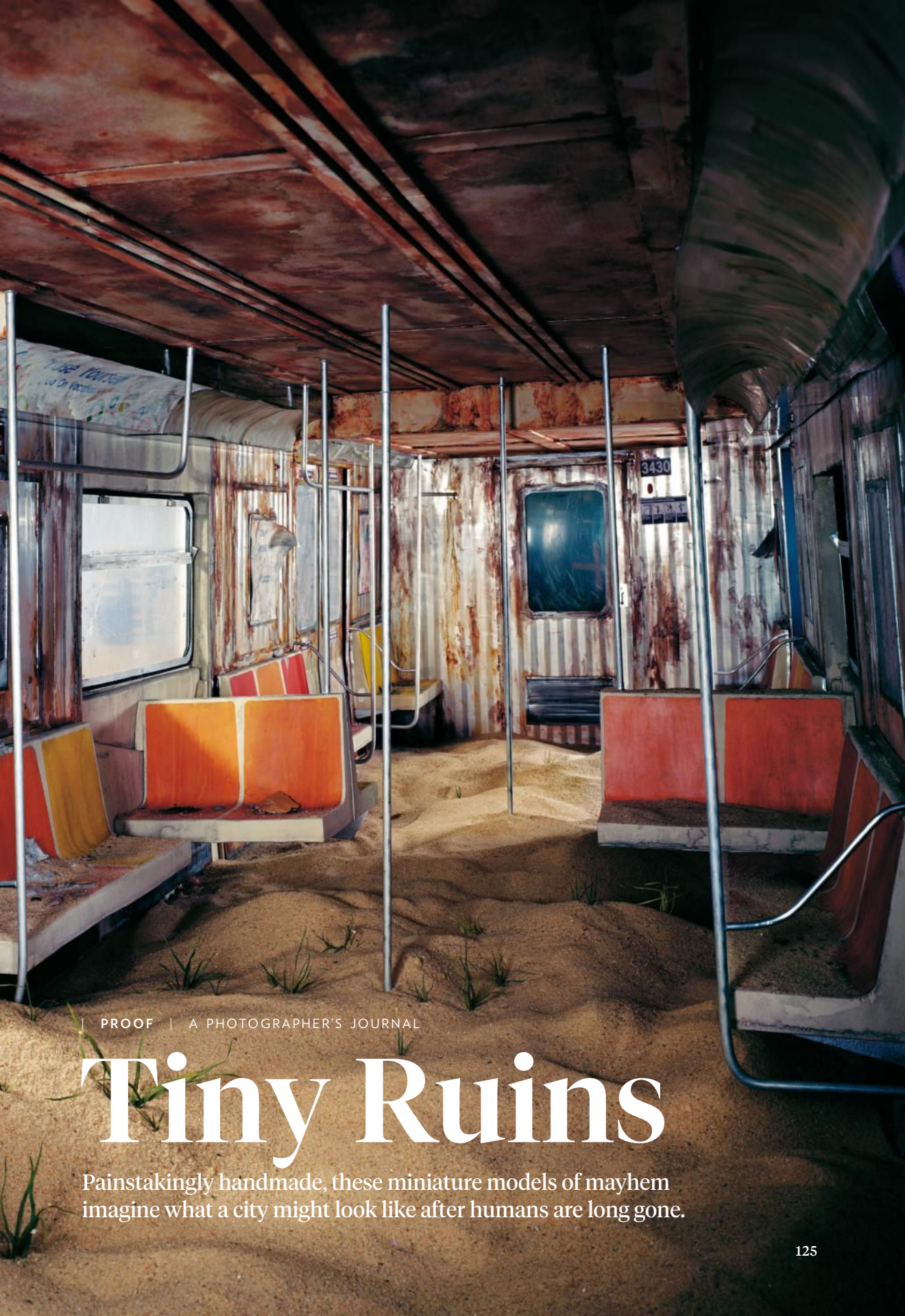
intact, the toilets still clean. Ali knew this wouldn’t last. His cousin Tayeb would begin the process of officially vouching for them. Hopefully they would soon move into his house or that of another relative. What he would do after that, Ali had no idea. ISIS had redefined life in Iraq. There would be no return to the past.

“I don’t care if they liberate Mosul,” he said. “I’m never going back.” □

James Verini has been writing for *National Geographic* since 2012. His first extended online feature, about the war in eastern Congo, won the 2014 George Polk Award for Magazine Reporting. **Moises Saman**, a Magnum photographer, was born in Lima, Peru. His work has received awards from World Press Photo, Pictures of the Year, and the Overseas Press Club.

Lori Nix and Kathleen Gerber spent seven months building this minute replica of a New York City subway car. Sprouting weeds and plastered with ironic posters, it sits in a desert. The city's skyline is visible beyond.





| PROOF | A PHOTOGRAPHER'S JOURNAL

Tiny Ruins

Painstakingly handmade, these miniature models of mayhem imagine what a city might look like after humans are long gone.



Nix and Gerber divide their labor. For this image of an anatomy classroom, says Nix, "I built the cabinets, the walls, the floors, and the chairs. Kathleen did all the anatomy models. She handles the difficult stuff."



By Jeremy Berlin
Photographs by Lori Nix
and Kathleen Gerber

The city is a ruin. Trains sit motionless on their tracks. Schools are silent. Libraries and laundromats languish in decay. Everyone has vanished.

It's the end of the world as we know it, but Lori Nix feels fine. In fact, she and Kathleen Gerber, her partner in art and life, are the cheerful architects of this apocalypse. On a gray winter day in Brooklyn, the two women are working in their chockablock apartment cum studio, carefully building small-scale dioramas of disaster.

Their goal, says Nix, is to create and photograph "open-ended narratives—models of a post-human metropolis in the future, after an unknown catastrophe." To "unlock, engage, and provoke" viewers' imaginations, "we want [them] to contemplate the present. Do we still have a future? Will we be able to save ourselves?"

Nix gets most of her ideas for these intricate tableaux from riding on the subway or paging through travel photos. Other inspirations spring from her past. Growing up in Tornado Alley in the 1970s, she was affected by extreme weather—and by disaster films like *The Towering Inferno* and dystopian fare like *Planet of the Apes*.

Today she considers herself a "faux landscape photographer." But "rather than traipse through the countryside looking for the perfect landscape, I just make it right here, on my tabletop."

That's where Gerber comes in. Her background in gilding, glassblowing, and faux finishing helps her build, distress, and age the sets.



"She's the sculptor," says Nix. "I'm the architect. I come up with the ideas and the color palettes and the camera angle. She does all the detail work—makes things come alive and shine."

Their Lilliputian sets range from 20 inches to nine feet in diameter. They're manufactured using common materials—paper and acrylic, cardboard and clay, extruded foam and plastic sheeting—and tiny power tools. It's a painstaking process: Each scene takes seven to 15 months to



build. When one is finally ready, Nix photographs it with an 8 x 10 large-format camera. A single final shot can take up to three weeks to produce.

“You wouldn’t know it from the work we do,” says Nix, “but I’m actually really optimistic. And I think our scenes—where nature is reclaiming the landscape—are weirdly hopeful.” Gerber agrees. “We’re always shooting for a mix of humor and horror,” she says. “We’re always trying to engage people—and get them to think.” □

As a child in tiny Norton, Kansas, Nix was “always around danger and disaster – bad weather, blizzards, floods, insect infestations. And of course, tornadoes.” In this shot of what may be a twister-ravaged beauty salon, Gerber’s hand enters the frame, illustrating the scale of these detailed dioramas.



A laundromat lies in ruins. Could an environmental disaster have caused it? "Every generation feels like it's on the downward slope," says Nix. "But it's really starting to feel like we're not going to be able to save ourselves."



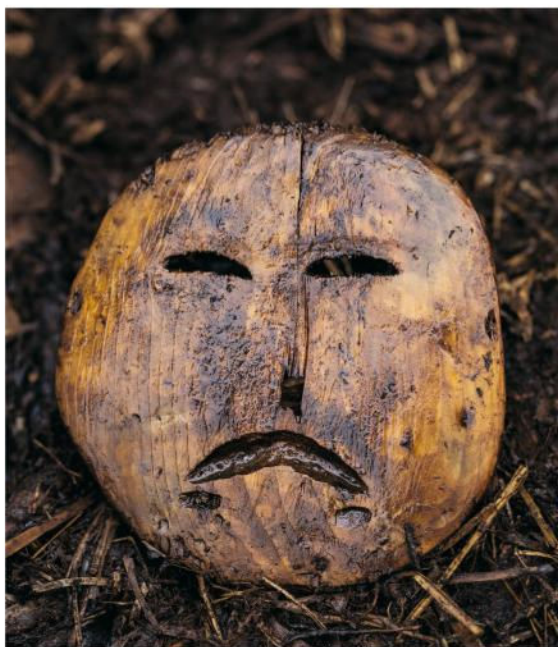




Nix and Gerber use a different scale for each set. They start with one object, then build the scene around it. For this library – where moss clings to the walls and birch trees shade the books – it was the dollhouse globe.



Emma Frances Echuck and her daughter Valerie take a break from drying salmon in the village of Quinhagak. At a nearby archaeological site artifacts such as this mask are emerging from the permafrost as it thaws.



RACING THE THAW

Warmer temperatures in Alaska are revealing native ancestral artifacts that have been frozen in time.





Fishermen line up to have their catches weighed during the 2015 commercial salmon season. This kind of work normally accounts for most of their annual earnings, but it may have come to an end. There was no buyer last year, so the men never launched their boats.

By A. R. Williams
Photographs by Erika Larsen

The archaeological site of Nunalleq on the southwest coast of Alaska preserves a fateful moment, frozen in time. The muddy square of earth is full of everyday things that the indigenous Yupik people used to survive and to celebrate life here, all left just as they lay when a deadly attack came almost four centuries ago.

Around the perimeter of what was once a large sod structure are traces of fire used to smoke out the residents—some 50 people, probably an alliance of extended families, who lived here when they weren't out hunting, fishing, and gathering plants. No one, it seems, was spared. Archaeologists unearthed the remains of someone, likely a woman, who appears to have succumbed to smoke inhalation as she tried to dig an escape tunnel under a wall. Skeletons of women, children, and elders were found together, facedown in the mud, suggesting that they were captured and killed.

As is often the case in archaeology, a tragedy of long ago is a boon to modern science. Archaeologists have recovered more than 2,500 intact artifacts at Nunalleq, from typical eating utensils to extraordinary things such as wooden ritual

masks, ivory tattoo needles, and a belt of caribou teeth. Beyond the sheer quantity and variety, the objects are astonishingly well preserved, having been frozen in the ground since about 1660.

The remains of baskets and mats still retain the intricate twists of their woven patterns. Break open a muddy, fibrous bundle and you'll find crisp, green blades of grass preserved inside. "This grass was cut when Shakespeare walked the Earth," marvels lead archaeologist Rick Knecht, a quiet, grizzled veteran of decades of digging.

Knecht, who's based at the University of Aberdeen in Scotland, sees a link between the destruction at the site and the old tales that modern Yupiks remember. Oral tradition preserves memories of a time historians call the Bow and Arrow Wars, when Yupik communities fought



This centuries-old ulu, or cutting tool, was plucked from the thawing ground at Nunalleq. Embodying the native Yupik belief that everything is constantly in transition, the handle can be seen as either a seal or a whale.

each other in bloody battles sometime before Russian explorers arrived in Alaska in the 1700s. Nunalleq offers the first archaeological evidence, and the first firm date, for this frightful period, which affected several generations of Yupiks.

Knecht believes the attacks were the result of climate change—a 550-year chilling of the Earth now known as the Little Ice Age—that coincided with Nunalleq’s occupation. The coldest years in Alaska, in the 1600s, must have been a desperate time, with raids probably launched to steal food.

“Whenever you get rapid change, there’s a lot of disruption in the seasonal cycles of subsistence,”

Knecht says. “If you get an extreme, like a Little Ice Age—or like now—changes can occur faster than people can adjust.”

Today increasingly violent weather has driven Nunalleq to the brink of oblivion. In summer everything looks fine as the land dons its perennial robe of white-flowering yarrow and sprigs of cotton grass that light up like candles when the morning sun hits the tundra. But the scene turns alarming come winter, when the Bering Sea hurls vicious storms at the coast. If the waves get big enough, they crash across a narrow gravel beach and rip away at the remains of the site.

The Arctic wasn’t always like this, but global

Heritage at Risk

The effects of global climate change threaten hundreds of sites that hold clues to Alaska's past. Permafrost once protected fragile artifacts from rot and mold, but warmer temperatures are now causing more and more of the icy ground to thaw in the southern part of the state. At the same time, seas are rising and winter storms are raging, putting sites all along the coast in danger.

ROUGH WEATHER


Increasingly powerful storms are battering the Bering Sea. Because thawed land is soft and porous and much of the protective, land-anchored sea ice has melted away, a single violent event can erode the coast as far as 100 feet inland.

LOCAL CONTROL

Native-owned corporations oversee the property and resources assigned to each group in a region or village.

 Alaska native land

Calista Alaska native regional corporation

 Archaeological site

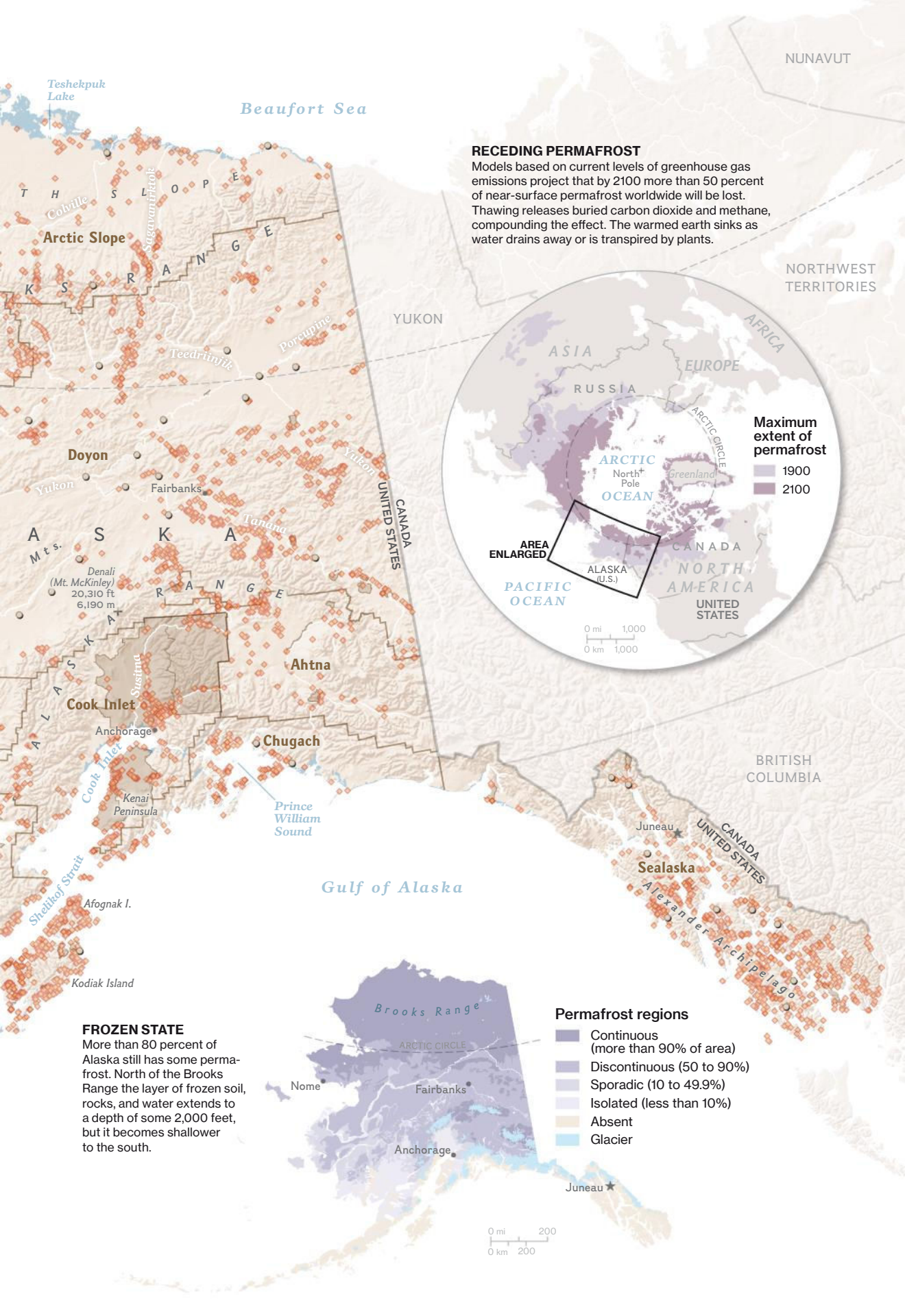
 Land vulnerable to inundation by a 10-foot storm surge

0 mi 100
0 km 100



DOUBLE HAZARD

As sea levels rise over the next 50 years, parts of Alaska's western coast will suffer storm surges that could regularly top 10 feet. Low-lying areas where thawing permafrost is causing the land to sink will be especially vulnerable.



NUNAVUT

Beaufort Sea

RECEDING PERMAFROST

Models based on current levels of greenhouse gas emissions project that by 2100 more than 50 percent of near-surface permafrost worldwide will be lost. Thawing releases buried carbon dioxide and methane, compounding the effect. The warmed earth sinks as water drains away or is transpired by plants.

NORTHWEST TERRITORIES

YUKON

CANADA
YUKON
UNITED STATES



Maximum extent of permafrost
 1900
 2100

AREA ENLARGED

PACIFIC OCEAN

0 mi 1,000
 0 km 1,000

BRITISH COLUMBIA

Gulf of Alaska

CANADA
UNITED STATES
Juneau
Sealaska
Alexander Archipelago

FROZEN STATE

More than 80 percent of Alaska still has some permafrost. North of the Brooks Range the layer of frozen soil, rocks, and water extends to a depth of some 2,000 feet, but it becomes shallower to the south.

Permafrost regions

- Continuous (more than 90% of area)
- Discontinuous (50 to 90%)
- Sporadic (10 to 49.9%)
- Isolated (less than 10%)
- Absent
- Glacier

0 mi 200
 0 km 200

Brooks Range

Nome Fairbanks

Anchorage

Juneau

Teshkepkuk Lake

Arctic Slope

Doyon

Cook Inlet

Ahtna

Chugach

Afognak I.

Kodiak Island

Cobville SLOPE

Sugamititok

Teedritjite

Porcupine

Tanana

Stusitna

Anchorage

Kenai Peninsula

Shelikof Strait

Prince William Sound

Denali (Mt. McKinley) 20,310 Ft 6,190 m

Fairbanks

Yukon

Yukon

Yukon

Yukon



When this wooden paddle blade from Nunalleq was new, people relied on kayaks to get around. Modern Yupiks use motorboats to visit other villages, hunt sea mammals, and net fish. Mike Smith (right) waded into the Kanektok River before work to hook a few salmon, which he gave to his grandmother. “She was so happy, she put on her apron right away and began cutting them up,” he says.





Archaeologist Rick Knecht (left) and community leader Warren Jones explore along the Arolik River after a local teacher saw a hunter's bow protruding from the eroding riverbank. They didn't find a site to excavate, but they investigated every possibility. "I'm not just going to sit back and let those things wash away," says Jones.

climate change is now hammering the Earth's polar regions. The result is a disastrous loss of artifacts from little known prehistoric cultures—like the one at Nunalleq—all along Alaska's shores and beyond. Ötzi, the Stone Age man whose body was found in 1991 as it emerged from a receding Italian glacier, is the most famous example of ancient remains brought to light by warmer weather. But a massive thaw is exposing traces of past peoples and civilizations across the northern regions of the globe—from Neolithic bows and arrows in Switzerland to hiking staffs from the Viking age in Norway and lavishly appointed tombs of Scythian nomads in Siberia. So many sites are in danger

that archaeologists are beginning to specialize in the rescue of once frozen artifacts. They're having to make hard choices, though. Which few things can they afford to rescue? And which will they just have to let go?

In coastal Alaska, archaeological sites are now threatened by a one-two punch. The first blow: average temperatures that have risen more than three degrees Fahrenheit in the past half century. As one balmy day follows another, the permafrost is thawing almost everywhere.

When archaeologists began digging at Nunalleq in 2009, they hit frozen soil about 18 inches below the surface of the tundra. Today the ground



is thawed three feet down. That means masterfully carved artifacts of caribou antler, driftwood, bone, and walrus ivory are emerging from the deep freeze that has preserved them in perfect condition. If they're not rescued, they immediately begin to rot and crumble.

The knockout blow: rising seas. The global level of oceans has risen about eight inches since 1900. That's a direct threat to coastal sites such as Nunalleq, which is doubly vulnerable to wave damage now that the thawing permafrost is making the land sink. "One good winter storm and we could lose this whole site," Knecht says.

He speaks from experience. Since the start of

the excavation, the relentless action of the sea has torn about 35 feet from the edge of the site. The winter after the 2010 dig was particularly brutal. Residents of Quinhagak, the modern village just four miles up the beach, remember huge chunks of ice slamming into the coast. By the time Knecht and his crew returned, the entire area they had excavated was gone.

Since then Knecht has pressed on with a renewed sense of urgency. Rain or shine, during the six-week dig season, about two dozen archaeologists and student volunteers spend long summer days on their hands and knees gently stripping away soil with their trowels.

ON AN AUGUST DAY that begins warm and buggy but soon turns overcast and cold, Tricia Gillam finds a common artifact that was created with exceptional artistry.

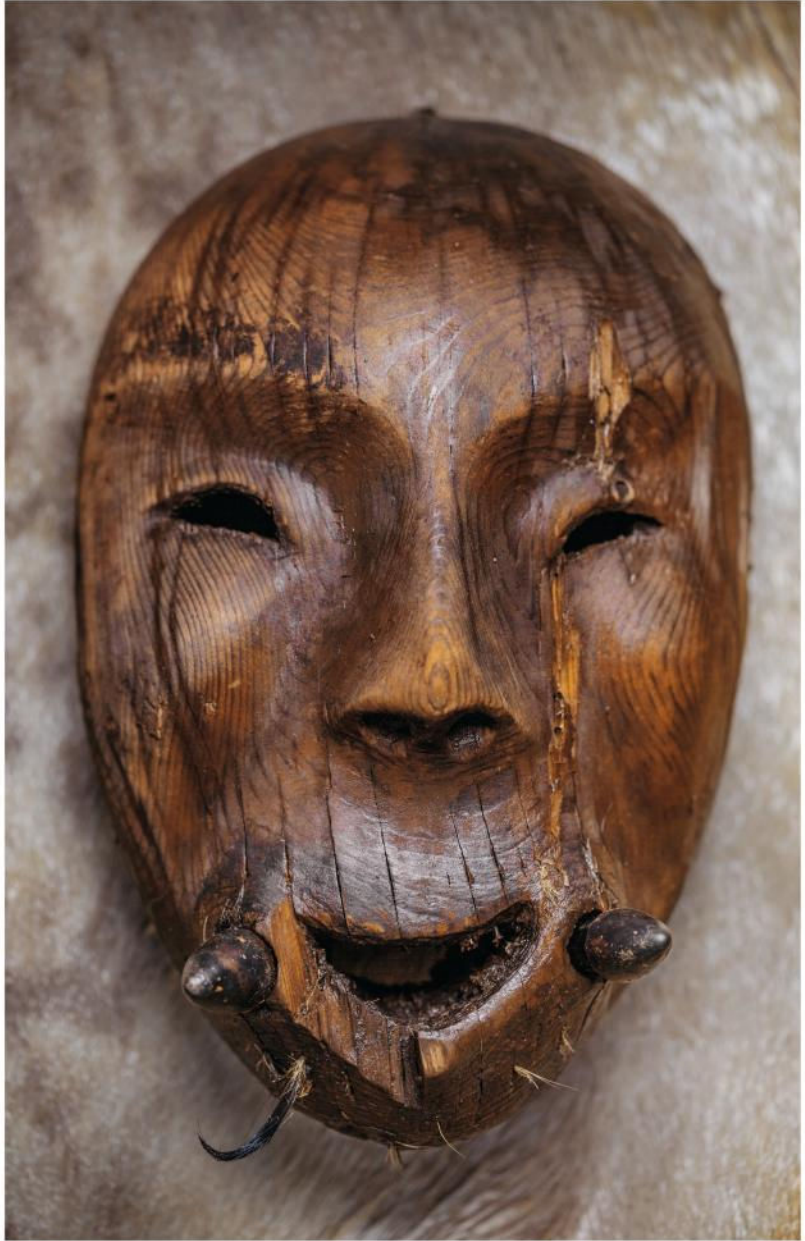
It's a women's cutting tool popularly called an ulu—*uluq* in Yupik—with a curved blade of slate and a carved wooden handle. The archaeologists often uncover a blade, a handle, or an occasional complete ulu, yet this one brings gasps from everyone. The handle has the graceful shape of a seal. But that's only half the design, it turns out. When local carver John Smith takes a look later from another angle, he sees the outline of a whale.

The artifact speaks to the fundamental Yupik worldview that nothing is a single, inflexible entity because everything is in a state of transformation. The ulu handle is a seal, but it's not a seal. It's a whale, but it's not a whale. Other finds embody that same idea: A mask that's a walrus, or a person. A small wooden box that's a kayak, or a seal.

"That dynamism is a constant part of their lives," Knecht says. "And climate change is part of that."

If anyone's going to survive the changes occurring in the natural world, he believes, it's these people who have always seen their environment as something fluid, requiring adjustments and adaptations. They know firsthand the seasonal patterns of plants and animals, and if there's a shift, they'll shift with it.





From a traditional lookout, hunters scan the tundra for moose. Land and sea are like supermarkets for the Yupik, who know exactly what foods to search for in each season of the year. Locals' ancestors carved the life-size mask above. Part human and part walrus, it was worn in a ritual dance to ensure a safe, successful hunt. "Even now, with rifles, going after a walrus is scary," says Knecht.



On a visit to 86-year-old Carrie Pleasant (right), Sarah Brown gets advice on sewing a beaver-skin parka. Pleasant made fur garments for all 10 of her children, but kids today usually wear store-bought clothing. “Things are changing so much,” she said wistfully. Pleasant has since passed away.

THE VILLAGE OF QUINHAGAK sits on Yupik land at the mouth of the Kanektok River, which winds across the tundra in wide loops before spilling into the Bering Sea. A few gravel streets run past a school, church, post office, supermarket, hardware store, health clinic, gas station, washateria, cell phone tower, and three sleek wind turbines that spin in the brisk sea breeze.

Officially, 745 people live here, in metal-roofed, wood-frame houses that perch on stilts a foot or so above the once frozen ground. But on any given day the actual population may be larger, swelled by relatives who have come to stay for several weeks, and residents of nearby villages

who have come to shop, visit friends, and maybe pull in a few fish.

Based in an office building that also serves as the archaeologists’ headquarters, 50-year-old Warren Jones is president of the local Yupik corporation known as Qanirtuuq, Inc., managing its 130,564 acres, overseeing its businesses and financial assets, and negotiating contracts with the outside world. But he’d really rather be hunting, he tells me. Along with almost everyone else here, he follows the same cycles of subsistence as the generations of Yupiks who came before him.

“Most of our diet is from the stuff we gather,



hunt, or fish,” he says. “My grandpa used to say, if you don’t have wood, fish stored away, berries, birds, you might as well be dead, because you don’t have nothing.”

Early August, when the excavation is in full swing, is a busy season for the villagers as they tap nature’s larder. Berries are ripening across the tundra, and fat coho salmon, known here as silvers, are swimming up the Kanektok on their way to spawn. In keeping with Yupik tradition, Misty Matthew helps her mother, Grace Anaver, gather food for the winter.

On the days she goes berry picking, Matthew drives an ATV deep into a flat, green landscape

dotted with others on the same mission, hunched over as they fill their plastic buckets. Salmonberries ripen first, one small, sweet, orange cloud per plant. Then blueberries, with a vivid, sweet-tart flavor that no supermarket fruit can match, and low-growing black crowberries that are crunchy and subtly sweet.

No one here thinks in pints. It’s gallons they need. Matthew stirs up some of her haul with sugar and fluffy shortening to make a snack called *akutaq*, or Eskimo ice cream. Then she makes jam in her grandmother’s old stainless steel pot, and jelly with the leftover juice. But the bulk of the picking goes into big chest freezers in a backyard shed. She opens all three to show me what her mother already has gathered. One is stuffed with berries in clear plastic bags. Another has berries, salmon, seal oil, trout, and smelt. The last holds moose, clams, geese, swans, caribou, and two kinds of wild greens.

“It’s good to be fat in this village. It means you’re eating well,” she says. “You’re supposed to have three years of food stored away to get you through the lean times.”

On another day, early in the morning, Matthew and her brother, David, take out their family’s motorboat to net salmon on the river. An hour later they bring 40 silvers, easily 20 pounds each, to the wooden drying racks along a quiet side creek where their mother is waiting. The two women spend the rest of the day gutting the fish, cutting fillets, and slicing strips for brining, drying, and smoking—everything done with deft strokes of their ulus.

Like many people who grew up here, Matthew has sometimes left Quinhagak to find work, but the people, the tundra, and the river keep pulling her back. Yet even after years away, she can see that the natural rhythms of life are out of whack.

“Everything’s two or three weeks ahead now,” she says as she cuts into a fish. “The salmon are late. And the geese are flying early. The berries were early too.”

IF THERE’S ONE THING everyone in Quinhagak agrees on, and talks about often, it’s all the changes brought by the weird weather.





Emma Fullmoon can count on younger relatives to provide food, like this salmon. And guests are always welcome in the home she shares with extended family. “That’s just what we’re supposed to do,” says her sister Fanny Simon. Though the Yupik idea of hospitality has endured, other customs have not. The wooden figure above has large, oval lip plugs, but no one today wears such ornaments.

“Twenty years ago the elders began to say the ground was sinking,” says Warren Jones, as we chat in his office. “The past 10 years or so it’s been so bad everybody’s noticed. We’re boating in February. That’s supposed to be the coldest month of the year.”

The strangest thing? Three successive winters without snow. On his computer, he pulls up a YouTube video made by a teacher at the village school. As the song “White Christmas” plays in the background, fourth graders try to ski, sled, and make snow angels on bare ground, in December.

Even without warmer winters, the children’s lives are very different from what their elders experienced. Qanirtuuq chairperson Grace Hill, 66, sees trends that concern her—like the fading language. “When I went to first grade, I only spoke Yupik. Now the kids only speak English,” she tells me in the fluent, slightly accented English that she learned in school. And then, of course, there’s the modern technology that’s changing everything everywhere. “The kids are more into computers—and they’re forgetting about our culture,” she worries.

Like other older villagers, Hill at first opposed the excavation of Nunalleq because Yupik tradition says ancestors shouldn’t be disturbed. But now she believes that archaeology can serve a greater good. “I’m hoping this will get the kids interested in their past,” she says.

Henry Small has the same thing in mind one sunny afternoon when he brings his 11-year-old daughter, Alqaq, to Nunalleq to check out the progress of the dig. This is their second visit this summer. When I ask him what he hopes his daughter learns here, he responds as if the answer were obvious: “Where she comes from!”

Alqaq, in a pink T-shirt, plaid capris, and movie-star sunglasses, is getting the message. On previous visits she has helped sort artifacts and

sift the excavated soil for small things the archaeologists might have overlooked. She especially likes the dolls, she says, and the lip plugs. And what about the ulus, like the one her father made for her birthday, with her name carved into the handle? “It’s cool that we get to use what our ancestors were using,” she says without hesitation. Today’s visit is brief, with no work to do, so Alqaq and her father soon head up the beach toward home on an ATV.

Archaeology’s potential to inspire such appreciation for the past is what motivated Jones to get the dig started. He asked Knecht to assess the eroding site, then helped convince the village’s board of directors that excavating Nunalleq was a good idea. He also got the board to fund the first two years of digging and provide ongoing logistical support. “It wasn’t cheap,” he says. “But to get the artifacts for our future generations, money didn’t matter.”

At the end of each field season the archaeologists have packed up what they’ve found and shipped it to the University of Aberdeen for conservation. But all the artifacts will be sent back later this year, destined for an old school building that Quinhagak has converted to a heritage center. Jones envisions this as a place where people can see, touch, and share stories about the beautifully worked possessions of their ancestors.

“I want our kids who are in college now to run it and be proud that it’s ours,” he says. And when this dream takes shape and the center opens its doors? “I want to be the first to go in and say, ‘I’m Yupik, and this is where I come from.’” □

Senior writer **A. R. Williams** covers archaeology and ancient cultures for the magazine. Passionate about places “where the landscape is extremely important to people,” **Erika Larsen** has photographed Sami herders in Scandinavia, tourists in Yellowstone, and writer Garrison Keillor in Minnesota.

The weather-bleached whale bones piled around clothesline poles in a Quinhagak backyard likely washed up on a beach nearby. Village elders remember bringing home dozens of whales every year, but those days are gone. Hunters now may make just a single catch on the open sea.



FURTHER

A GLIMPSE OF WHAT'S NEW AND NEXT



ART THERAPY

By Catherine Zuckerman

Butterflies are abundant in the Central African Republic. It is home to nearly 600 identified species, many brilliantly colored, some as big as a saucer. Clouds of the fluttering insects often appear suddenly—a striking contrast to a landscape that's been ravaged during the past four years by a brutal civil war.

Farmer Philippe Andé finds solace in the creatures. For four decades he has been collecting butterfly wings from his fields and turning them into works of art. With nothing more than tweezers, a razor, and some rubber cement, Andé

carefully assembles the wing sections to render scenes of Central African life: a boy harvesting coconuts, women pounding cassavas to make flour, the nation's multihued flag (above). Each tableau is like a stained glass window, says *National Geographic* senior editor Peter Gwin, who writes about the country in next month's issue.

Andé began creating these pieces so he could sell them to tourists to supplement his income. But because the area has become so plagued by violence, customers are now scarce.

Still Andé keeps at his art. It's a form of healing, he says, a way of capturing his country's true beauty and recalling the peacefulness it once had.



This *Graphium poli-cenes* is one of nearly 40 species of swordtail butterflies known to inhabit Africa.

To go FURTHER into what life is like in the war-torn Central African Republic, read Peter Gwin's feature story in the May issue of *National Geographic*.

FOLLOW YOUR CURIOSITY

TRAVEL WITH NATIONAL GEOGRAPHIC



 NATIONAL
GEOGRAPHIC
EXPEDITIONS

Call 1-888-966-8687 or visit natgeoexpeditions.com

CULTURAL & WILDLIFE EXPEDITIONS | SMALL-SHIP VOYAGES | PHOTOGRAPHY TRIPS & WORKSHOPS
PRIVATE EXPEDITIONS | FAMILY EXPEDITIONS | PRIVATE JET TRIPS | ACTIVE ADVENTURES
TRAIN TRIPS | UNIQUE LODGES OF THE WORLD | STUDENT EXPEDITIONS | AND MORE!

Photo: Hoof prints riddle the sand as gemsboks trot across Namibia's Namib Desert.

ONE BIG PROMISE

30,000
QUALITY CHECKS

Do you know what's
in your pet's food?
Purina tracks and
inspects every ingredient
so it's 100% safe and
you can lead a worry-free,
healthy life together.
That's big.

#letslivebig

Purina trademarks are owned by Société des Produits Nestlé S.A.

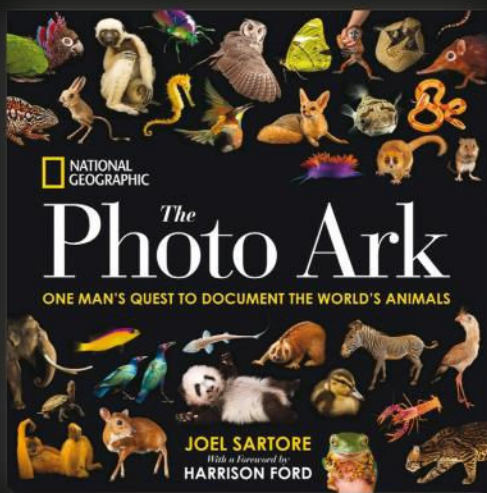


Your Pet, Our Passion.

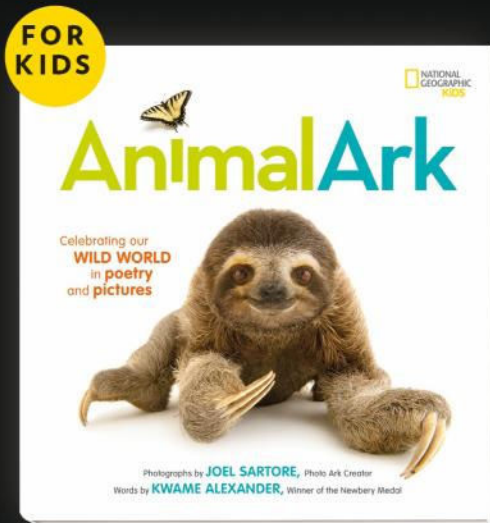


“I WANT PEOPLE
TO CARE, TO FALL
IN LOVE, AND TO
TAKE ACTION.”

—**Joel Sartore**



INCLUDES A FOREWORD BY **HARRISON FORD**,
VICE CHAIR OF CONSERVATION INTERNATIONAL



WRITTEN BY NEWBERY MEDALIST
AND POET **KWAME ALEXANDER**

FOR MANY OF EARTH'S CREATURES, TIME IS RUNNING OUT.

Joel Sartore, founder of The Photo Ark, pledged to photograph every animal species in captivity and inspire people to care and take action. Filled with stunning and exquisite photographs, these books gloriously showcase the infinite variety of the animal kingdom and convey a powerful message with humor, poetry, compassion, and art.

AVAILABLE WHEREVER BOOKS ARE SOLD
AND AT NATIONALGEOGRAPHIC.COM/BOOKS



NATGEOBOOKS



@NATGEOBOOKS

NATIONAL
GEOGRAPHIC
PHOTOARK
JOEL SARTORE

NATIONAL
GEOGRAPHIC

© 2017 National Geographic Partners, LLC

